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CHARLES C. MILLER

A REPORT PRESENTED TO THE GRADUATE COMMITTEE
OF THE DEPARTMENT OF CIVIL ENGINEERING IN
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TOTAL QUALITY MANAGEMENT IN CONSTRUCTION

The principles of Total Quality Management (TQM) provide a means for achieving quality in the construction process. The improvement of quality requires that every member of the organization embrace the principles of continuous improvement. Total Quality Management is a customer-oriented approach that stresses the effective use of people. Total Quality Management also emphasizes the application of quantitative methods and process improvement techniques to continually improve products and services.

Total Quality Management requires a cultural change in the organization. The leadership and management of the organization must demonstrate a sincere commitment to continuous improvement. They must foster a working environment which capitalizes on the creativity and ingenuity of employees. The TQM organization focuses on the needs and expectations of customers, both internal and external. Emphasis is placed on prevention of the causes of defects rather than the correction of defects. The organization must foster a long-term relationship with suppliers based on mutual trust and respect. Total Quality Management encourages innovation and application of new technology and procedures to enhance quality improvement.

The process of continuous improvement applies to all aspects of the organization including administrative, engineering and production functions.

Project teams are instrumental in the improvement of quality, productivity and processes. They focus on quality improvement of processes and problem solving, and instill quality leadership principles throughout the organization. The training and education of employees is also a key factor to successful quality improvement.

Quality in the construction process is based on several fundamental concepts. These concepts include the definition and assignment of responsibilities, the importance of teamwork, understanding requirements and expectations, and principles of good communication. As Western organizations place more emphasis on process control techniques, there is a trend toward statistical quality control in the construction industry.

The implementation of Total Quality Management involves the application of the principles of continuous improvement. These principles include constancy of purpose, commitment to quality, customer focus and involvement, process orientation, continuous improvement, system-centered management, investment in knowledge, teamwork, conservation of human resources, total involvement and perpetual commitment.

The *Malcolm Baldrige National Quality Award* was established to promote quality awareness and to recognize the contributions of U.S. business to the nation's economic growth. The award recognizes continuous quality improvement through statistical quality control, a prevention style of management and a systems approach for data collection and customer feedback.

Top management must spearhead the movement toward continuous improvement and actively participate in the TQM process. Former Vice President Dan Quayle said, "President Bush believes we must establish a firm commitment to Total Quality Management and the principle of continuous quality improvement . . . the taxpayers have every right to expect and demand high quality — and that is what we must deliver."

All organizations must embrace the principles of Total Quality Management to survive in today's highly competitive environment. Through commitment to continuous quality improvement, designers, construction managers and constructors can design and build facilities that meet and exceed the expectations of customers.

CHAPTER 1
DEFINING TOTAL QUALITY MANAGEMENT

PHILOSOPHY

The new approach to management allows organizations to keep pace with rapidly changing conditions. Japanese companies have successfully applied Total Quality Management principles while American companies are only starting to put them into practice.

The decline of American companies has been attributed to poor management practices and management seeking short-term profits and good performance.[1] Dr. W. Edwards Deming argues that "a better way to serve stockholders would be to stay in business with constant improvement of quality of product and service, thus to decrease costs, capture markets, provide jobs and increase dividends."[2]

Deming suggests that because a production system is stable, improvement of quality is the responsibility of management.[3] Management must also recognize the distinction between a stable and unstable system.[4] A stable system is

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[1]Mary Walton, The Deming Management Method (New York: The Putnam Publishing Group, 1986), p. xi.

[2]Ibid.

[3]W. Edwards Deming, Out of Crisis (Cambridge: Massachusetts Institute of Technology Center for Advanced Engineering Study, 1986), p. 1.

[4]Walton, p. xii.

achieved "by removal, one by one, of special causes of trouble, best detected by statistical signal."[5]

Deming questioned twenty-two production workers as to why productivity increases as quality improves. The production workers attributed the increase in productivity to "less rework" and "not so much waste".[6] Deming states that "quality to the production worker means that his performance satisfies him, provides to him pride of workmanship."[7]

The improvement of quality reduces waste in terms of both man-hours and machine-time leading to production of better products and services.[8] This process results in a chain reaction of "lower costs, better competitive position, happier people on the job, jobs and more jobs."[9]

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[5]Ibid.

[6]Deming, p. 1.

[7]Ibid.

[8]Ibid., p. 2.

[9]Ibid.

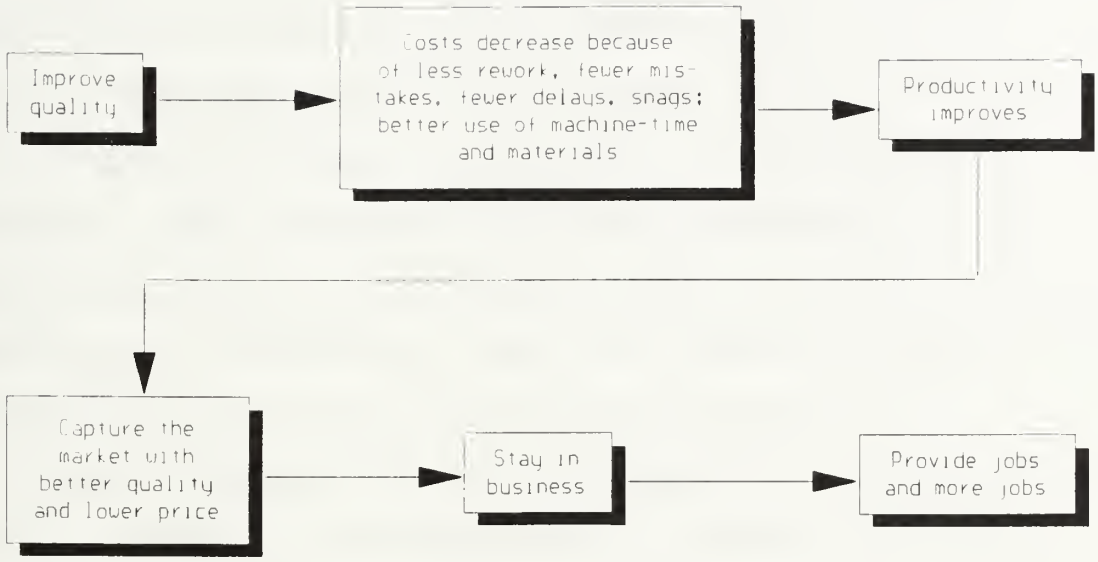

Figure 1 The Deming chain reaction.

Deming describes the awakening of Japanese management to the positive relationship between quality and productivity. In the late 1940s, Japanese engineers found that productivity does improve as variation is reduced.[10] Figure 1 above shows the chain reaction that "became engraved in Japan as a way of life."[11] Since Japanese management embraced this chain reaction in the early 1950s,

[10]Ibid., p. 3.

[11]Ibid.

the Japanese have aggressively pursued the common goal of improving quality.

Deming views the concept of production as a system. The flow chart shown in figure 2 below illustrates how quality improvement touches every aspect of the production system from procurement of materials to the consumer or customer.[12] This system orientation of production is equally applicable to any manufacturing, service or construction organization. Note that Deming includes construction in his list of service organizations.[13]

Deming explains that it is necessary to establish with suppliers "a long-term relationship of loyalty and trust to improve the quality of incoming materials and to decrease

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[12]Ibid., p. 4.

[13]Ibid., p. 184.

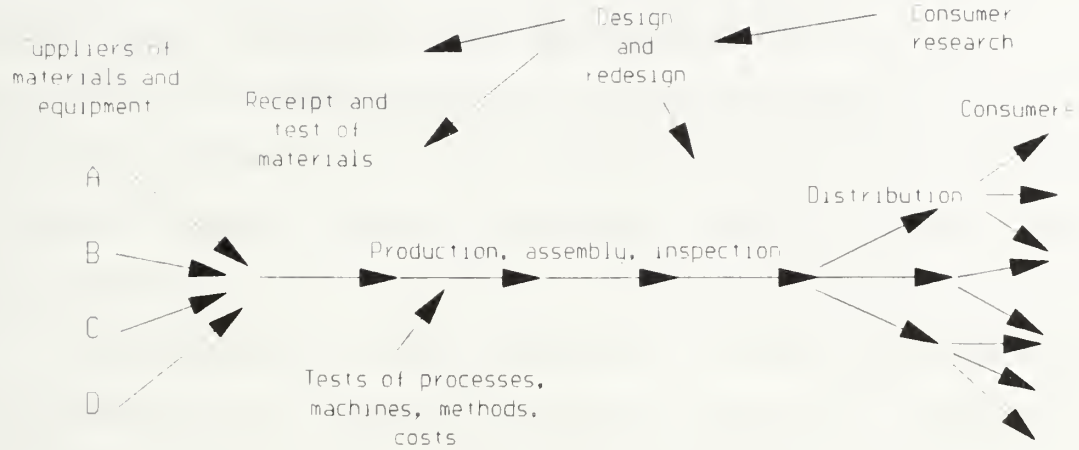

Figure 2 Deming's view of production as a system.

costs."[14] However, the most important part of the production system is the consumer or customer. Quality improvement should therefore be focused on customer requirements.[15] Again, this philosophy is applicable not only to manufacturing and service industries but also the construction industry as well.

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[14]Ibid., pp. 4-5.

[15]Ibid., p. 5.

Deming asserts that quality is based upon the intent of management. Engineers and others translate this intent into plans, specifications, tests and production.[16] Deming attributes the transformation of Japanese industry and their economic success to the above principles, the chain reaction shown in figure 1 and the production system flow chart shown in figure 2.[17]

Deming explains that management in Japan sought quality improvement with constancy of purpose and total commitment. Japanese engineers learned valuable statistical methods to identify the causes of variation. They also learned that continuous improvement of processes is crucial to quality improvement.[18]

Deming contends that in most governmental services there is no market to capture.[19] Rather than capturing the market, government agencies should deliver services required by law or regulation in an economical manner.[20] Deming states that "continual improvement in government service would earn appreciation of the American public and would hold jobs in the service, and help industry to create more

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[16]Ibid.

[17]Ibid.

[18]Ibid.

[19]Ibid., p. 6.

[20]Ibid.

jobs."[21] Along with economic delivery of services, government agencies should strive to deliver services which meet the quality expectations of their customers.

Deming suggests that measures of productivity do not lead to improvement in productivity.[22] He compares measures of productivity to statistics on accidents. The statistics "tell you all about the number of accidents in the home, on the road and at the work place, but they do not tell you how to reduce the frequency of accidents."[23] Nevertheless, productivity studies can be useful to determine if activities are consistent with organizational goals and the cost of activities.[24]

The answer to the question of how to improve quality and productivity is not "by everyone doing their best."[25] Everyone must have knowledge of how to achieve a "system of improvement" in addition to putting forth their best efforts.[26] The system of improvement includes Deming's "Fourteen Points" and elimination of the "Seven Deadly Diseases and Obstacles"[27]

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[21]Ibid.

[22]Ibid., p. 15.

[23]Ibid.

[24]Ibid., p. 16.

[25]Walton, p. 32.

[26]Ibid.

[27]Ibid.

Deming's Fourteen Points of management foster continuous improvement and a new attitude toward work. Brian E. Mansir and Nicholas R. Schacht portray Deming's management concepts in terms of a "Continuous Improvement Process" model. They describe the Continuous Improvement Process (CIP) as "a means by which an organization creates and sustains a culture of continuous improvement."[28] They further describe the process:

> The organization deliberately seeks to create a positive and dynamic working environment, foster teamwork, apply quantitative methods and analytical techniques and tap the creativity and ingenuity of all its people. Collective effort is focused to better understand and meet internal and external customer needs and to continuously increase customer satisfaction.[29]

Mansir and Schacht claim that organizations employing the Continuous Improvement Process can significantly improve quality of their products and services, increase productivity and reduce costs.[30]

The Continuous Improvement Process involves the total organization in working toward improvement.[31] Top management must foster a "cultural environment" which

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[28]Brian E. Mansir and Nicholas R. Schacht, An Introduction to the Continuous Improvement Process: Principles & Practices (Falls Church, Virginia: Educational Services Institute, 1990), p. v.

[29]Ibid.

[30]Ibid.

[31]Ibid., p. 1-8.

encourages continuous improvement.[32] Mansir and Schacht contend that "the process involves every member of the organization, applies to every activity and focuses on creating and managing change to assure success and survival."[33]

Top management directs the improvement process by creating an environment which inspires creativity, pride, teamwork and knowledge enrichment.[34] Management must establish a unified effort toward quality improvement at every level in the organization. The improvement process is directed toward achievement of organizational goals by continuous improvement of performance in areas such as quality, cost, schedule, manpower development, new product development and most importantly customer satisfaction.[35]

Mansir and Schacht describe a hierarchical relationship between the key elements of the Continuous Improvement Process. Figure 3 depicts the interrelationships among the CIP elements.[36] The organization's philosophy is comprised of its purpose, vision and theory.[37] Next, management principles include basic concepts, rules and assumptions

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[32]Ibid.

[33]Ibid.

[34]Ibid.

[35]Ibid.

[36]Ibid., p. 1-12.

[37]Ibid., p. 1-11.

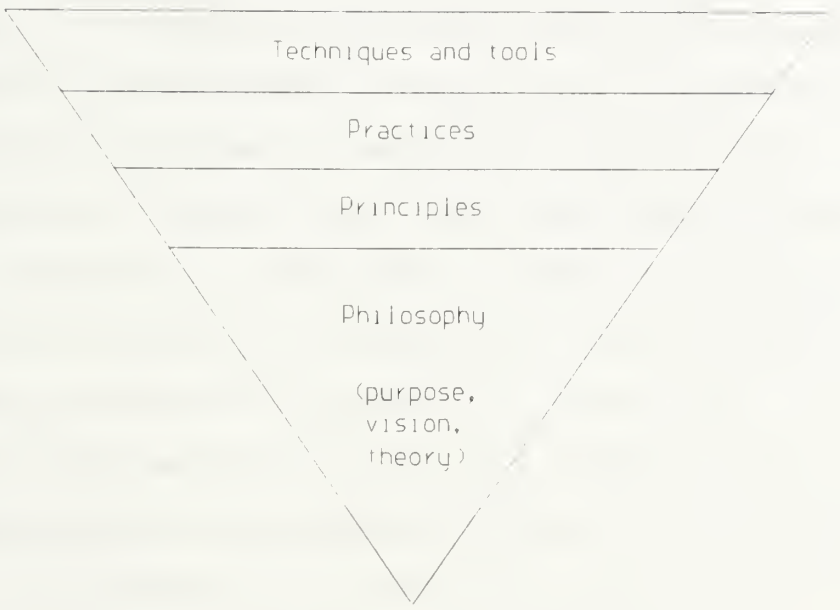

Figure 3 Mansir and Schacht's view of CIP elements.

which are the foundation for continuous improvement practices.[38] The organization's practices are behavior and actions based on established continuous improvement principles.[39] Lastly, techniques and tools are the methods and procedures used for attainment of CIP goals.[40]

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[38]Ibid.

[39]Ibid.

[40]Ibid., pp. 1-11 - 1-12.

Mansir and Schacht define an organization's philosophy as "its shared system of values, motivating principles and concepts."[41] A competitive organization today consistently evaluates its philosophy to ensure that it advances the principles of continuous improvement and customer satisfaction.[42] Mansir and Schacht describe five components of an organization's philosophy. First, the organization's philosophy is based on an underlying theory "that defines the need for collective action."[43] Second, the organization's members must share a common purpose. Third, the organization's philosophy contains "a vision that focuses their actions on a desired transformation."[44] Fourth, the organization prescribes a set of values which provides the groundwork for acceptable behavior. Lastly, an organization establishes policies which outline the basic principles and requirements of the organization's philosophy.

The philosophy of the CIP organization is based on some underlying theory which "crystallizes the need for improvement."[45] Mansir and Schacht suggest that survival of the organization is the basis for many underlying

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[41]Ibid., p. 2-1.

[42]Ibid.

[43]Ibid.

[44]Ibid., pp. 2-1 - 2-2.

[45]Ibid., p. 2-2.

theories.[46] Specifically, they propose a basic theory that may be applicable to many organizations whether they are a commercial business such as a construction company, a defense industry or a Government organization: "Organizations that understand the needs of their customers and that continuously improve their processes, products and services accordingly will survive, and the others will cease to be relevant."[47]

The CIP organization must establish a clear statement of purpose to unite and focus each of its members. This explanation of purpose is equally important for both public and private sector organizations.[48] Deming's first of his Fourteen Points states, "Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business and to provide jobs."[49] Mansir and Schacht provide an example of a statement of purpose:

> Our purpose is to ensure long-term security for each stakeholder through continuously improving customer satisfaction and competitive position, increasing market share, employment opportunities and job security and providing a competitive return on long-term investments.[50]

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[46]Ibid.

[47]Ibid.

[48]Ibid., p. 2-3.

[49]Deming, p. 23.

[50]Mansir and Schacht, p. 2-4.

The organization's philosophy contains a shared vision which guides the thinking and actions of its members.[51] The organization's vision formulates "a desired future state" and "reflects an ideal".[52] For instance, the Harris Government Systems Sector (GSS) vision states:

> We want GSS to be the premier supplier, i.e., the supplier of choice in competitive procurement in each of our market areas as visualized by our customers, our employees and the corporation. This reflects our image as well as the quality of our offering and product.[53]

The organization's values comprise not only legal principles but also ethical considerations as well.[54] These priorities are communicated through clear statements and management actions.[55] They set the stage for how the organization functions and the behavioral expectations of its members.

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[51]Ibid., p. 2-5.

[52]Ibid., p. 2-5 - 2-6.

[53]Ibid., p. 2-6.

[54]Ibid.

[55]Ibid.

The policies of the organization should reflect the fundamental principles of its philosophy and the concept of continuous improvement.[56] For example, the Ralph M. Parsons Company quality policy reads:

> We are committed to performing quality work for our clients. We will do this as a company and as individuals by completely understanding the requirements we have to meet and by meeting these requirements the first time.[57]

Mansir and Schacht suggest that a separate policy statement should review the process of continuous improvement.[58] They provide an example of a policy statement by Harris Government Systems Sector (GSS) which states, "It is the policy of GSS to continuously improve performance in every area of our business. Continuous improvement shall be a vital part of our strategic planning. . . ."[59]

The Department of the Navy renamed Total Quality Management to reflect the Navy's traditional emphasis on leadership. The new name for the Navy's approach is Total Quality Leadership (TQL). The Chief of Naval Operations,

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[56]Ibid., p. 2-7.

[57]The Ralph M. Parsons Company, "Quality Improvement Fundamentals," May 1991.

[58]Mansir and Schacht, p. 2-7.

[59]Ibid.

Admiral Frank B. Kelso II, emphasizes Total Quality Leadership as indicated in this policy statement he sent Navy-wide:

> The Chief of Naval Operations Executive Steering Committee has developed a statement of mission, vision and guiding principles for U.S. naval forces, to be used in implementing Total Quality Leadership Navy-wide. The statement reads:
>
> The Navy-Marine Corps team is the world-recognized premier naval and expeditionary force, fully capable of conducting operations in support of U.S. national objectives in an unpredictable global economic and political environment.
>
> Our mission is to provide combat ready forces to support the requirements of the unified commanders so our nation can deter aggression, encourage political stability, provide forward presence, establish sea control and project power from the sea against any threat and win.
>
> Our vision is a naval force that has the full support of the American people and advances the bounds of personal excellence, dedication and integrity; technology; joint expeditionary and combined operations; combat tactics and doctrine; maintenance, logistic support and staying power; and quality of life for our people.
>
> We will be guided by the following principles:
> - Value tradition but encourage and embrace innovation.
> - Include education and training as an integral part of our mission.
> - Safeguard people, resources and the environment.
>
> We will:
> - Accomplish our mission through teamwork.
> - Train and equip our forces to operate with the Army, Air Force, Coast Guard, our friends and allies.
> - Provide a clear and accurate portrayal of our capabilities and operations for all.
> - Make decisions in the best interests of our mission, putting aside parochialism and old habits.
> - Promote the dignity of our people and their families.
> - Provide top notch service to all.

We are committed to:
- Honesty, integrity and the highest standards of moral and ethical conduct.
- Equal opportunity for all.
- Open and effective communications.
- Quality and continuous improvement.
- Decisions based upon data and knowledge.
- Being good stewards of the taxpayers' resources.
- Maintaining the chain of command.

As we progress toward full implementation of TQL, the mission, vision and guiding principles will ensure we are all working toward a common purpose.[60]

Rear Admiral Jack E. Buffington, Commander, Naval Facilities Engineering Command promotes quality support to the Navy. Admiral Buffington asserts, "We are committed to Total Quality Leadership and will continue to phase it into how we conduct our business."[61] Advocating quality support through people, he says, "We have placed people who know the business best closer to the customer, and we have delegated more decision making to them."[62]

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[60]Admiral Frank B. Kelso II, "CNO Stresses TQL," Navy Civil Engineer, Fall 1991/Winter 1992, p. 27.

[61]Rear Admiral Jack E. Buffington, "Quality Support to a Changing Navy," The Military Engineer, March-April 1993, p. 29.

[62]Ibid.

THE TEAM CONCEPT

Peter R. Scholtes advocates the use of project teams to improve quality, productivity and processes.[63] Underpinning Scholtes' approach to project management are three elements.[64] First, the approach highlights the quality improvement principles taught by Dr. W. Edwards Deming. Second, data-based methods drawn from statistics and "classical logic" are used in the approach.[65] Scholtes refers to the application of data as the "scientific approach".[66] Third, guidelines are provided for building and maintaining groups, planning and managing projects and conducting productive meetings.

Scholtes discusses the new approach to management referred to as "Quality Leadership".[67] This approach emphasizes quality improvement rather than short-term profits. Organizations are more effectively meeting the needs of customers by "learning how to monitor, control and constantly improve production systems."[68] Scholtes contends

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[63]Peter R. Scholtes, The Team Handbook: How to Use Teams to Improve Quality (Madison, Wisconsin: Joiner Associates, Inc., 1988), p. I-1.

[64]Ibid., pp. I-1 - I-2.

[65]Ibid., p. I-1.

[66]Ibid., p. I-1.

[67]Ibid., p. 1-1.

[68]Ibid., pp. 1-1 - 1-2.

that decision making in Quality Leadership organizations is based on the application of data rather than speculation. The aim of the organization "is on improving *how* work gets done (the methods) instead of simply *what* is done (the results)."[69]

Scholtes suggests that a Quality Leadership approach restructures the relationships between employees and management.[70] The role of the manager is to assist the employees in doing the "best job possible", anticipating and removing barriers that deter employees from producing quality work.[71] Employees contribute the knowledge gained on the job to improve processes.[72]

Scholtes and Joiner Associates use the triangle shown in figure 4 to represent Deming's theories.[73] Each corner of the triangle represents an essential ingredient found in a successful organization.[74] The first corner represents the quality expectations of the customer, the focus of the organization. The second corner depicts the data-based or scientific approach for continuous improvement of processes. The third corner portrays the members of the organization

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[69]Ibid., p. 1-2.

[70]Ibid.

[71]Ibid.

[72]Ibid.

[73]Ibid., p. 1-4.

[74]Ibid.

Figure 4 **The Joiner triangle for successful organizations.**

"working together as 'all one team'" in learning about quality improvement principles.[75] Scholtes compares the triangle to a three-legged stool.[76] Together, the elements form a stable system. But when the organization is lacking one of the elements, ". . . the result is disaster."[77]

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[75]Ibid.

[76]Ibid.

[77]Ibid.

Scholtes says the transformation to Quality Leadership is a demanding task that requires the dedication and commitment of top management and others in the organization.[78] He points out that project teams are just one component in the Quality Leadership process.[79] Furthermore, important to understanding project teams is an understanding of the shortcomings of other management techniques.

A common management practice in the United States is called Management by Objectives or Management by Results. This technique features the traditional chain of command approach. Performance objectives in the form of numerical goals or quotas are established at the top of the organization and then filtered down through a chain of accountability. Scholtes maintains that the shortcomings of the Management by Results approach originate from the reliance on numerical goals.[80] Management by Results places insufficient emphasis on processes and systems, "the real capabilities of the organization as a whole."[81] Scholtes suggests that workers, supervisors and managers alike are guided by the arbitrary numerical goals, and consequently,

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[78]Ibid.

[79]Ibid.

[80]Ibid., p. 1-5.

[81]Ibid.

may lose sight of the overall purpose and vision of their organization.[82]

Scholtes attributes several problems to the use of numerical goals in judging and directing performance.[83] First, short-term thinking results from a system of numerical objectives and quotas. Short-term efforts are foremost when survival of the organization depends on attainment of long-term objectives. Second, reliance on numerical goals leads to a misguided focus. Achievement of numerical goals does little to expand the capability of the system. Only improvement of the system can expand capability. Third, an environment of numerical objectives provokes internal conflict. The standards applicable to one part of the organization may not conform with the standards of another part. The resulting conflicts may lead to a breakdown of teamwork and cohesiveness. Fourth, the numerical goals may be unreachable and beyond the capability of the system. The employees "are forced by the system to fudge figures, alter records or just 'play the game' — to work around the system instead of improving it."[84] Scholtes suggests that the worst shortcoming of Management by Results is greater fear. The employees are fearful "of what will happen if orders are not followed exactly, of not getting a

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[82]Ibid.

[83]Ibid., pp. 1-5 - 1-8.

[84]Ibid., p. 1-7.

raise or a promotion, of being out of favor or losing a job."[85] Lastly, Management by Results fosters a "blindness to customer concerns".[86] Success is measured in terms of meeting a numerical goal rather than providing quality products or services and satisfying the customer.[87]

Project teams are an important component in the Quality Leadership process. Scholtes states that project teams are an integral part of a "company-wide transformation strategy.[88] The role of teams includes the identification of key processes or areas needing improvement. Managers take part in guidance teams that supervise project teams which are responsible for finding problem solutions.[89]

Project teams not only focus on quality improvement of processes but also instill the principles of Quality Leadership throughout the organization.[90] Scholtes mentions several lessons provided by an organization's project teams.[91] Members of a project team learn how to work together as a team and they learn how to use scientific methods to improve processes. Team leaders learn techniques

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[85]Ibid.

[86]Ibid., p. 1-8.

[87]Ibid.

[88]Ibid., p. 1-17.

[89]Ibid.

[90]Ibid., p. 1-18.

[91]Ibid., pp. 1-18 - 1-20.

for planning and managing projects and designing and conducting meetings. Managers in charge of guidance teams also learn about scientific techniques and they learn how to guide a team's progress.

Projects allow empowerment of employees at lower levels in the organization because decision-making is shifted downward. Team members learn that quality improvement is hard work and "managers learn they need to be patient."[92]

Scholtes states that project teams aid in the development of internal experts trained in quality improvement techniques.[93] Initial projects enable these technical experts to enhance their proficiency in training and instruction. Project teams also improve quality improvement efforts by making presentations and by involving others in the process.

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[92]Ibid., p. 1-19.

[93]Ibid.

QUALITY IMPROVEMENT PROCESS

The Ralph M. Parsons Company is an example of a design-construction firm dedicated to continuous quality improvement. Their quality policy clearly states that they are committed to performing quality work for their clients. The company describes their quality improvement initiatives as the Parsons Quality Improvement Process (QIP).[94] The process begins with the commitment and involvement of top management.[95] It enables employees to fully understand the performance requirements expected of them. The process improves efficiency and eliminates waste by promoting teamwork and improving problem solving capabilities.[96]

The Parsons QIP is based on the quality management concepts taught by Philip Crosby, Dr. W. Edwards Deming and Dr. J. M. Juran.[97] Parsons has applied these quality management principles to their specific type of work in development of the Parsons QIP. Parsons contends that these principles "have been developed into a systematic and practical approach for improving quality."[98]

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[94]Parsons, p. 1.

[95]Ibid.

[96]Ibid.

[97]Ibid.

[98]Ibid.

The groundwork for the Parsons Quality Improvement Process is four quality improvement fundamentals called "the absolutes of quality".[99] These fundamentals are presented as answers to questions:[100]

- What is quality? **Conformance to Requirements**
- How do we achieve it? **Prevention**
- What is our performance standard? **Zero Defects**
- How can we measure quality? **Cost of Doing Things Wrong**

Parsons defines quality as conformance to requirements.[101] Quality work is produced when there is an understanding of the requirements and when the firm meets those requirements.[102] Quality is achieved by systematic prevention of errors. Parsons claims that "keeping errors from happening is more cost-effective than fixing them after they occurred."[103] Parsons' performance standard is zero defects. Zero defects implies 100 percent conformance to the requirements.[104] Each employee must embrace the concept that technical, schedule or budget nonconformance is not

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[99]Ibid.

[100]Ibid.

[101]Ibid., p. 2.

[102]Ibid.

[103]Ibid.

[104]Ibid.

acceptable.[105] Parsons' measurement of quality is the price of nonconformance or the cost of rework.[106] As the cost of rework decreases, the quality of the work improves.[107]

The Parsons Quality Improvement Process uses quality improvement tools or methods based on the premise that "all work is a process."[108] The firm creates a work process model to assist in problem solving. The model aids in identifying specific input, output and production requirements necessary to produce desired results.[109]

Parsons outlines seven elements that comprise their quality improvement program.[110] The first four elements constitute the fundamental structure of the QIP. These elements are organization, education, awareness and recognition. The remaining elements allow each Parsons employee to set in motion the principles of quality improvement. They are defining requirements, measurement and corrective action.

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[105]Ibid.

[106]Ibid.

[107]Ibid.

[108]Ibid.

[109]Ibid.

[110]Ibid., p. 3.

Parsons maintains that the QIP began with the commitment of the company president and that commitment to the process has migrated to every part of the organization.[111] Conversely, each employee has the opportunity to initiate personal and companywide actions to improve quality and eliminate problems.[112]

Emphasizing the team approach, Parsons established a QIP organization based on quality management functions for the company, divisions, departments, projects and groups.[113] Figure 5 portrays the Parsons Quality Improvement Process organization.[114]

The Quality Improvement Steering Committee oversees the Quality Improvement Team (QIT). The steering committee provides the support and resources necessary for implementation of the QIP.[115] The steering committee demonstrates the solid commitment to quality improvement

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[111]Ibid.

[112]Ibid.

[113]Ibid.

[114]Ibid., p. 4.

[115]Ibid., p. 3.

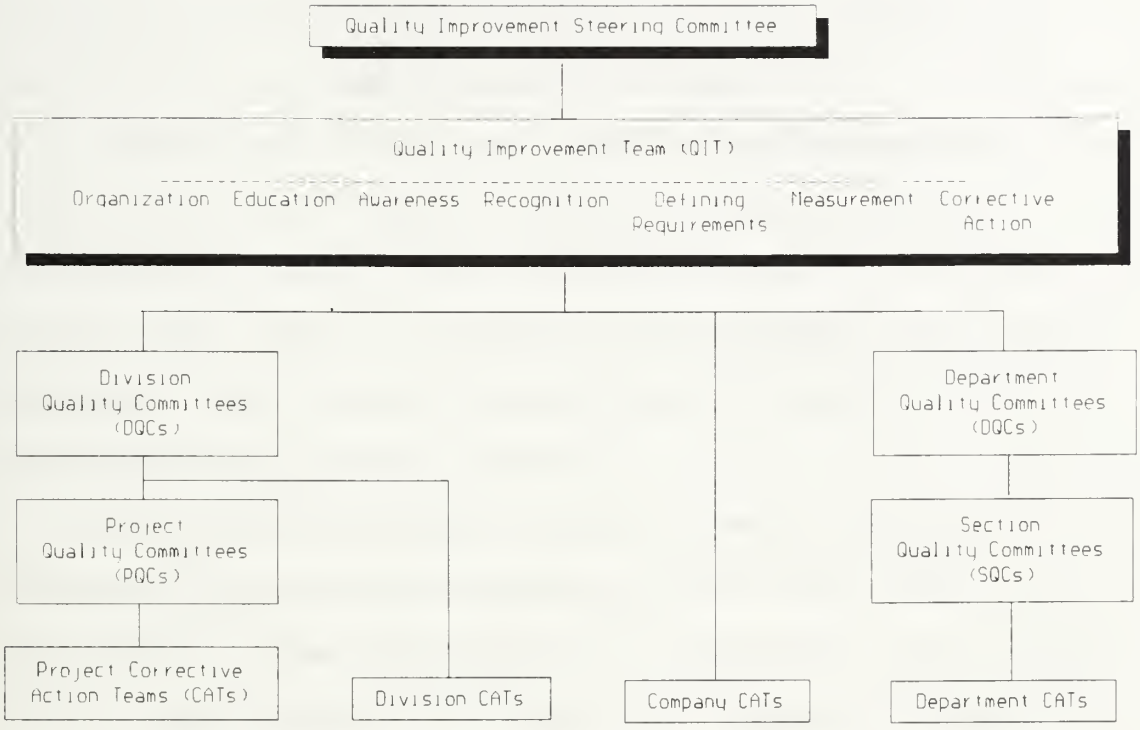

Figure 5 The Parsons Quality Improvement Process organization.

by top management.[116] The president of the company is the chairman of the steering committee.

The Quality Improvement Team provides "working-level" implementation of the seven element quality process, advancing the vision and principles of the steering committee.[117] Parsons asserts that "the successful

[116]Ibid.

[117]Ibid., p. 4.

implementation of the QIP requires a total company understanding, acceptance and participation."[118]

The Quality Improvement Team reviews companywide Corrective Action Requests (CARs) from departments or divisions within the firm. The QIT assigns Corrective Action Teams (CATs) to identify and recommend solutions to problems. CATs normally evaluate only interdivision or interdepartment problem areas.[119]

Division or Department Quality Committees (DQCs) implement the seven QIP elements within their division or department. These committees are directed by the division or department manager and other key personnel within the division or department participate. The DQCs administer the quality process by:[120]

- Organizing the DQC per QIP guidelines.

- Promoting the QIP programs for training, awareness and recognition.

- Creating division or department procedures for key work activities.

- Measuring and analyzing performance of key work activities.

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[118]Ibid.

[119]Ibid., p. 5.

[120]Ibid., pp. 5-6.

- Taking corrective action and, if needed, assigning CATs to make recommendations for improvement of key functional areas.

Project managers in the firm place as much emphasis on quality improvement as they do on the cost and schedule aspects of a project.[121] Division managers may establish Project Quality Committees (PQCs) for certain projects to focus on quality issues. The PQC is comprised of representatives from each functional area assigned to the project such as engineering, procurement and supervision.

Project managers conduct routine quality improvement meetings. Using a team-building approach, these meetings focus on "quality-related items" including:[122]

- Definition and communication of the scope of work at every level on the project.

- Effective use of standard company procedures.

- Improving the relationship with customers and suppliers.

- Measuring and analyzing performance.

- Effectiveness of the corrective action process.

- Effectiveness of division, department and Corrective Action Team support for the project.

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[121]Ibid., p. 6.

[122]Ibid., pp. 6-7.

Parsons advises that "discussions regarding existing problems focus on finding ways of improving methods for producing work that conforms to requirements — not on assigning blame."[123] Employees are encouraged to provide suggestions for preventing problems.[124] The objective of "error-free work" is emphasized during these productive QIP meetings.[125]

Parsons promotes the attitude of "Quality Improvement Through Teamwork".[126] But the detailed application of QIP concepts in the work place is a difficult task.[127] Parsons claims that:

> . . . the PQCs provide the "workshop" or clearinghouse for the project's team members so that specific problems are addressed and ways are developed to apply the QIP principles, concepts and working tools to the individual's work processes.[128]

Parsons considers employee education as a critical element in the implementation of the QIP. The firm conducts "Quality Improvement Fundamentals" classes and seminars to provide each employee with the necessary quality improvement techniques.[129]

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[123]Ibid., p. 7.

[124]Ibid.

[125]Ibid.

[126]Ibid.

[127]Ibid.

[128]Ibid.

[129]Ibid.

Parsons defines awareness as "the recognition of multiple forms of communication presented in an open, constant manner to describe all aspects of the QIP."[130] Parsons communicates quality awareness through the company magazine, posters and articles in the "Parsons Perspective".[131] The objectives of Parsons awareness efforts include:[132]

- Confirm the commitment of top management to the QIP.
- Keep all employees informed of successful QIP efforts.
- Provide straightforward information about the QIP to prevent any misunderstandings.
- Provide additional education opportunities.
- Assist management in recognition of employee efforts.

Parsons considers the special recognition of employee contributions as an important part of the quality process. The firm established a companywide recognition program to reward quality improvement achievements. Individuals or groups that improve the overall level of quality are given recognition awards.[133]

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[130]Ibid., p. 8.

[131]Ibid.

[132]Ibid., pp. 8-9.

[133]Ibid., p. 10.

Parsons defines a process as "an orderly series of actions or steps that achieve a result such as producing a product for our customer."[134] The progress of work depends on a clear definition of the requirements, "expressing the customer's or supplier's needs and expectations for each work step."[135] Parsons suggests that sound business relationships based on mutual respect and trust result when all the participants in a project attempt to understand the requirements of others.[136] Additionally, good relationships are developed through open communication. Quality improvement is enhanced because ". . . honest and open communication encourages the clarification of either the input or the output requirements for the work processes."[137]

Quality is achieved through conformance to defined requirements.[138] However, tolerances are allowed for the output of a work process.[139] For example, Parsons prepares construction cost estimates that vary from -5 percent to +30 percent for a conceptual construction estimate and ±5 percent for a definitive construction estimate.[140]

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[134]Ibid., p. 11.

[135]Ibid., p. 12.

[136]Ibid.

[137]Ibid.

[138]Ibid.

[139]Ibid.

[140]Ibid.

Parsons contends that working with customers in identifying requirements assists in minimizing changes.[141] For instance, changes are minimized by helping the customer determine the amount of detail needed on engineering drawings and specifications.

After defining the output requirements, the next step is to define a specific process scope.[142] Input and supplier information are considered when defining the process scope.

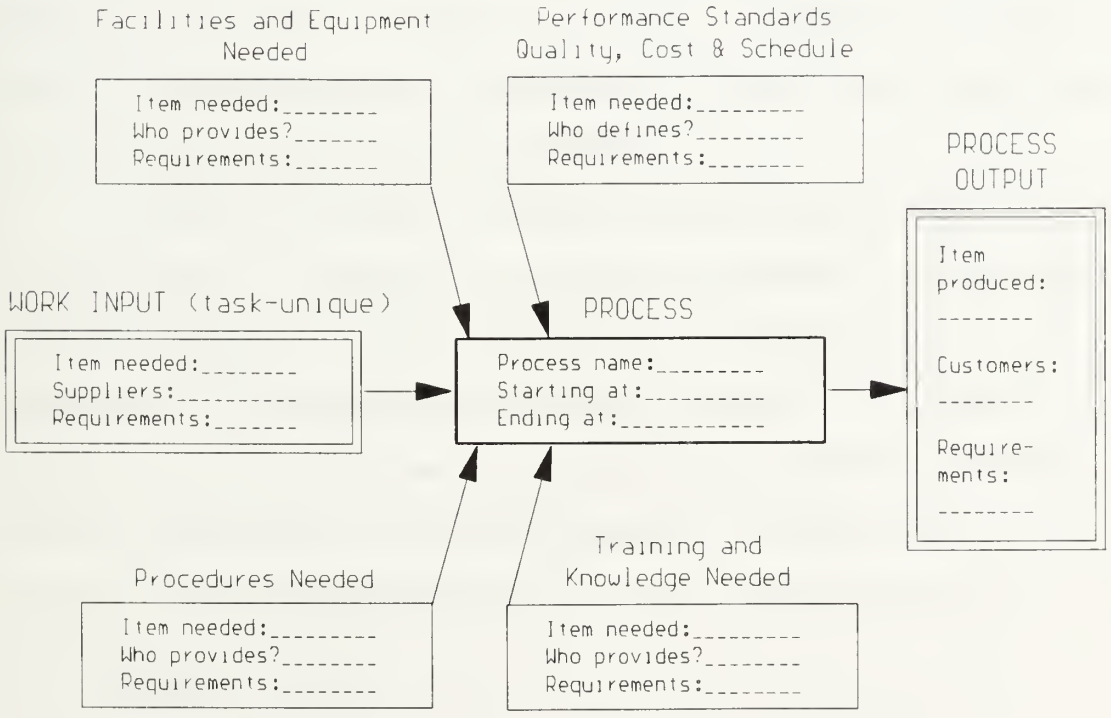

Figure 6 Parsons' work process model.

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[141]Ibid.

[142]Ibid., p. 13.

Parsons uses a work process model to aid in identification of all input and output requirements. Figure 6 shows the work process model used at Parsons.[143] The model is a "conceptual tool" that enables application of the QIP elements to a project.[144]

The Parsons QIP uses measurement as a tool for process improvement. A specific process baseline is determined for analysis. Information suitable for measurement includes such items as time, the number of steps, redundant events, delays and errors.[145] The collection and analysis of data and the communication of measurement results are important for successful process improvement.

Corrective action involves the analysis and elimination of problems.[146] Problems or "nonconformances" are identified by measurement.[147] Wrong dimensions on a drawing, information missing from the specification or untimely reports for the customer are examples of nonconformances.[148] Parsons discusses a logical sequence of events for eliminating nonconformances.[149] First, the problem is

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[143]Ibid., p. 14.

[144]Ibid.

[145]Ibid.. p. 17.

[146]Ibid., p. 19.

[147]Ibid.

[148]Ibid.

[149]Ibid.

defined and a plan for the solution is formulated. Second, a temporary "quick fix" allows the firm to stay in business. The quick fix does not provide a permanent solution, but only minimizes the immediate effects of the problem.[150] The third step is identification of the root causes. The root causes are then eliminated by taking corrective action. Next, the process is evaluated to determine if the change solved the problem. A "follow up" is conducted to prevent recurrence of the problem and to identify any side effects.[150]

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[150]Ibid.

[150]Ibid.

CHAPTER 2
TOTAL QUALITY MANAGEMENT PRINCIPLES

DEMING'S FOURTEEN POINTS

Deming argues that the "Western style of management must change to halt the decline of Western industry, and to turn it upward."[151] The system of improvement or transformation is accomplished through the application of Deming's Fourteen Points and elimination of the Seven Deadly Diseases and Obstacles.

The Fourteen Points are applicable to any type of organization including a government agency, a manufacturing company or a construction company. By adopting the following Fourteen Points, management sends a positive signal of continuous improvement to employees, investors and customers alike:[152]

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business and to provide jobs.
2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities and take on leadership for change.
3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

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[151]Deming, p. 18.

[152]Ibid., pp. 23-24.

4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.

5. Improve constantly and forever the system of production and service, to improve quality and productivity and thus constantly decrease costs.

6. Institute training on the job.

7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.

8. Drive out fear, so that everyone may work effectively for the company.

9. Break down barriers between departments. People in research, design, sales and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

10. Eliminate slogans, exhortations and targets for the work force asking for zero defects and new levels of productivity.

11a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.

b. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.

12a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.

b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, *inter alia*, abolishment of the annual or merit rating and of management by objective.

13. Institute a vigorous program of education and self-improvement.

14. Put everyone in the company to work to accomplish the transformation. The transformation is everybody's job.

Point 1: Create contancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business and to provide jobs.

William W. Scherkenbach suggests that the constancy of purpose advocated by Deming is based on a "customer-driven,

team-fueled and even-keel approach to business."[153] The challenge for top management is to operationally define customer requirements to remain competitive in today's international marketplace.[154] The constancy of purpose necessary to meet the expectations of customers is established by making policy and by long-range planning.[155]

Rather than focusing on short-term results, the organization should strive to stay in business and provide jobs through innovation, research and education, continuous improvement of product and service and maintenance of equipment and fixtures.[156] Mary Walton advises that plans to stay in business should answer the following questions:[157]

- What materials will be required, at what cost?
- What will be the method of production?
- What new people will have to be hired?
- What changes in equipment will be required?
- What new skills will be required, and for how many people?
- How will current employees be trained in these new skills? How will supervisors be trained?
- What will be the cost of production?
- What will be the cost of marketing? What will be the costs and methods of service?
- How will the product or service be used by the customers?
- How will the company know if the customer is satisfied?

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[153]William W. Scherkenbach, The Deming Route to Quality and Productivity: Road Maps and Roadblocks (Washington, D.C.: CEEpress Books, 1991), p. 10.

[154]Ibid., p. 11.

[155]Ibid.

[156]Walton, p. 34.

[157]Ibid., p. 56.

Deming states that innovation is achieved only when "there is faith that there will be a future" and when top management exhibits "unshakable commitment to quality and productivity."[158] Innovation also depends on the appropriate investment in research and suitable education for employees.

Successful organizations must constantly improve products and services. Deming cautions that producing the wrong product or offering the wrong service may force an organization out of business even if the employees are faithfully working towards improving efficiency.[159] Furthermore, the investment in the maintenance of equipment, furniture and fixtures and in new aids to production is essential for product improvement.[160]

Point 2: Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities and take on leadership for change.

Acceptance of the new philosophy is essential to remain competitive in the new economic age. Walton contends "quality must become the new religion."[161] We must end the practice of accepting mistakes, defects, unsuitable materials and inadequate training.[162]

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[158]Deming, p. 25.

[159]Ibid., p. 26.

[160]Walton, p. 57.

[161]Ibid., p. 58.

[162]Deming, p. 26.

Scherkenbach discusses why there has not been widespread acceptance of Deming's philosophy in the nited States. Scherkenbach says that the new philosophy represents a major change, a "revolution", and that most people exhibit a natural resistance to major change.[163] He cites other quality experts who call for "evolution" and advocates a less drastic change in management philosophy.[164] But to stay competitive and successfully meet the demands of customers, management in America must recognize the need for major change, a quality revolution.

Point 3: Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

Deming suggests that "100 percent inspection to improve quality is equivalent to planning for defects, acknowledgement that the process has not the capability required for the specifications."[165] Quality is achieved through improvement of the production process rather than through inspection or detection of defects.[166]

A system of mass inspection involves identifying defects in the product, followed by scrapping or rework.[167] The scrap and rework in turn increases costs. Deming

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[163]Scherkenbach, p. 22.

[164]Ibid.

[165]Deming, p. 28.

[166]Ibid., p. 29.

[167]Scherkenbach, p. 26.

recommends that inspection is best accomplished "at the right point for minimum total cost."[168] Statistical control is achieved through the inspection of small samples of product for use in process control charts.[169] Deming compares the old and new way of doing business: "The old way: Inspect bad quality out. The new way: Build good quality in."[170]

Point 4: End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.

Deming advocates a long-term relationship with suppliers for reducing costs.[171] Long-term relationships foster an environment where suppliers invest in continuous improvement unlike short-term ventures. Yet, finding a single supplier that consistently meets all requirements and demonstrates constant improvement is a difficult task.[172]

Deming stresses that "price has no meaning without a measure of quality being purchased."[173] Awarding business to the low bidder ultimately results in low quality and higher

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[168]Deming, p. 29.

[169]Ibid., pp. 29-30.

[170]Walton, p. 60.

[171]Deming, p. 35.

[172]Scherkenbach, p. 131.

[173]Deming, p. 32.

costs.[174] Deming argues that "American industry and the U.S. government, civil and military, are being rooked by rules that award business to the lowest bidder."[175]

The basis for choosing suppliers should be not only on the cost of products and services but also on the quality of those products and services.[176] Scherkenbach advises that suppliers need to exhibit continual use of statistical control procedures, while buyers should have the appropriate knowledge to effectively interpret the statistical information provided by the suppliers.[177]

Point 5: Improve constantly and forever the system of production and service, to improve quality and productivity and thus constantly decrease costs.

Deming says ". . . that quality must be built in at the design stage" and teamwork at this stage is key to the process of continuous improvement.[178] Test methods are subject to constant improvement and each team member should strive for a better understanding of the needs and expectations of customers.[179]

Every member of the organization must embrace constant improvement. Every activity participates in the process,

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[174]Ibid.

[175]Ibid.

[176]Scherkenbach, p. 132.

[177]Ibid.

[178]Deming, p. 49.

[179]Ibid.

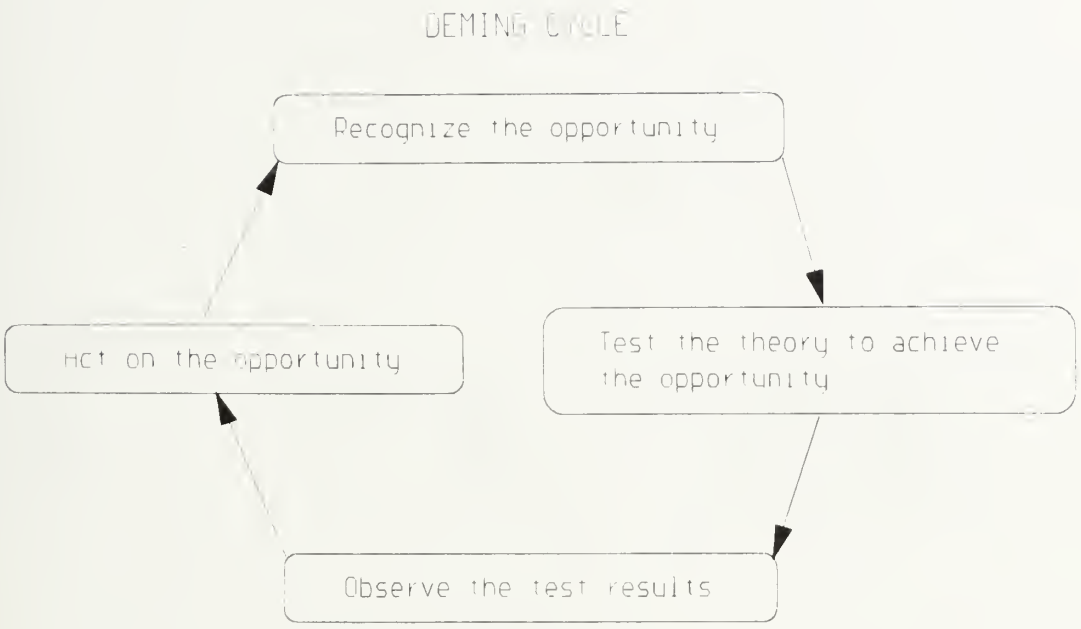

Figure 7 The Deming Cycle.

including not only manufacturing or service activities but also purchasing, transportation, engineering, maintenance, sales, personnel, training and accounting.[180]

Figure 7 shows the Deming Cycle, "a procedure for the improvement of analytical problems or opportunities.[181] The procedure consists of four steps. Scherkenbach links the Process of Continuous Improvement shown in figure 8 to the

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[180]Walton, p. 66.

[181]Scherkenbach, pp. 35-36.

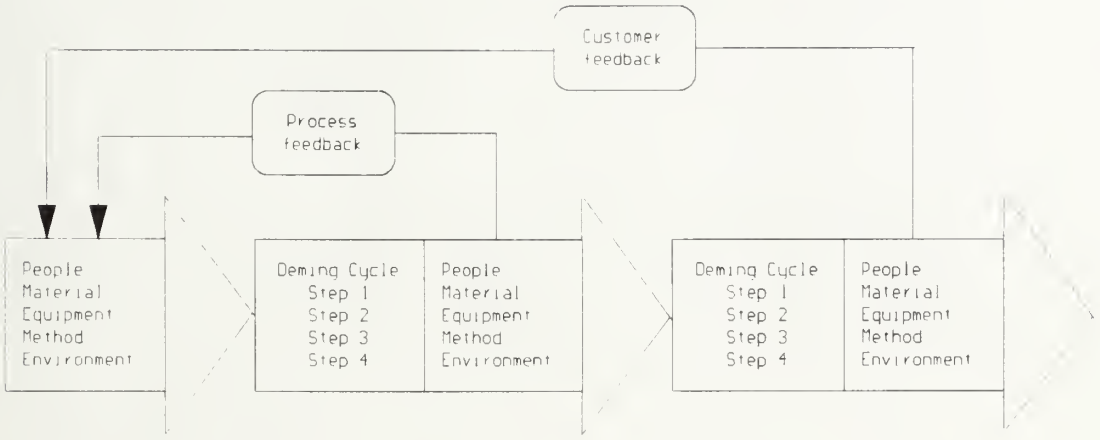

Figure 8 Scherkenbach's Process of Continuous Improvement.

Deming Cycle.[182] He emphasizes that the process "spirals toward a customer target."[183]

Step 1: Recognize the opportunity. Scherkenbach suggests that we operationally define the opportunity by gaining a better understanding of customer requirements.[184] The opportunity for improvement shown in figure 9 is represented by the distance between the feedback specified by the customer in the customer feedback loop and the

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[182]Scherkenbach, p. 35.

[183]Ibid.

[184]Ibid., pp. 36-37.

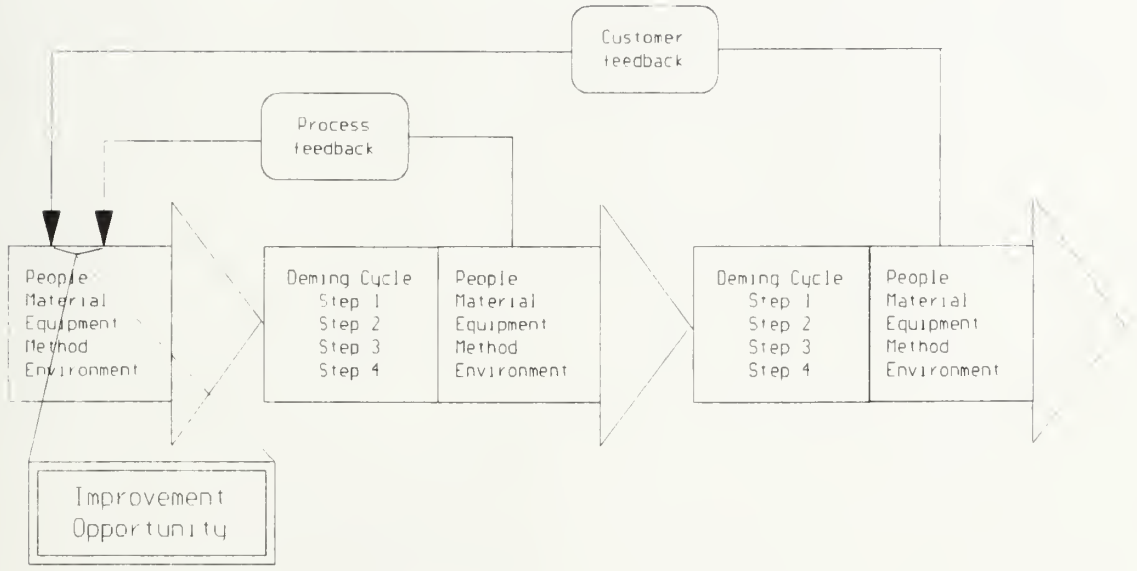

Figure 9 Operationally define the opportunity.

process performance specified by the process feedback loop.[185] As the two feedback loops approach each other, the opportunity to improve decreases while the capability of the process increases.[186] The variability of the process also decreases making "it possible to have higher quality at lower cost."[187]

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[185]Ibid., pp. 36-37.

[186]Ibid., p. 37.

[187]Ibid.

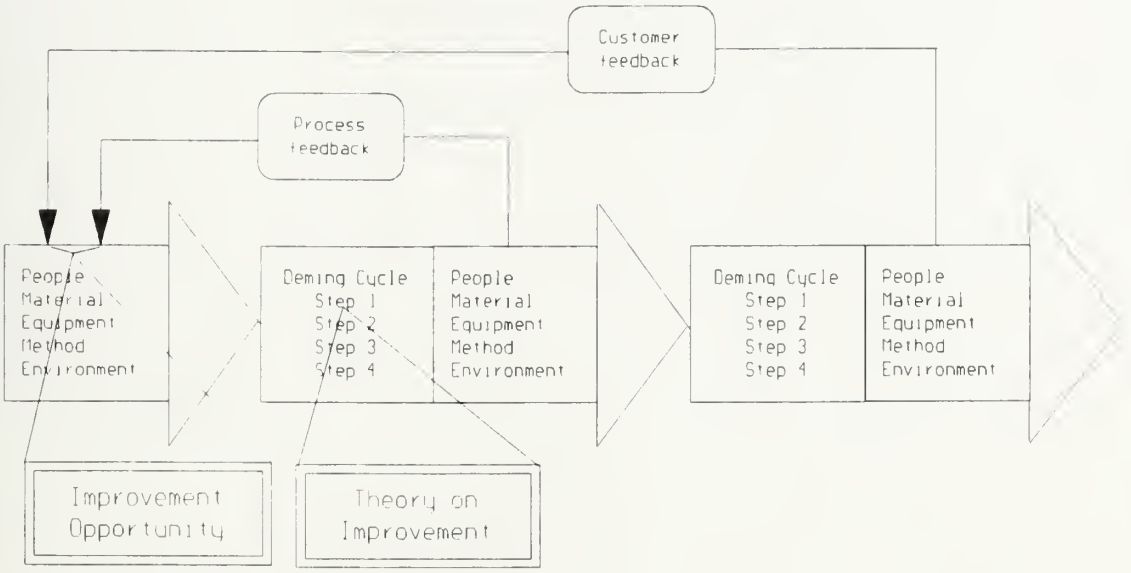

Figure 10 Operationally define the theory.

After operationally defining the opportunity, the theory "on how to realize the opportunity" is operationally defined.[188] Figure 10 illustrates the theory which "could start with a hunch or it could be as certain as a law of nature or physics."[189] The theory is accompanied by a plan

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[188]Ibid.

[189]Ibid., pp. 37-38.

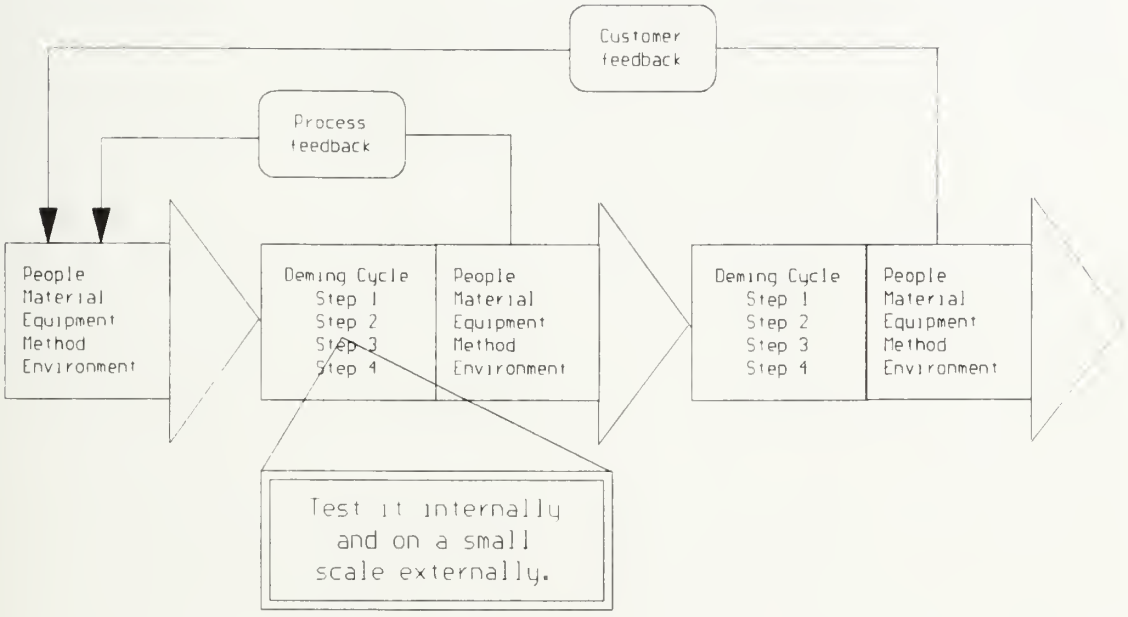

Figure 11 Test the theory.

for testing to make "rational predictions" of the process performance.[190]

Step 2: Test the theory. Scherkenbach recommends that testing should be conducted internally in a production environment or laboratory and externally on a small scale with customer participation.[191] This participation increases

[190]Ibid., p. 38.

[191]Ibid.

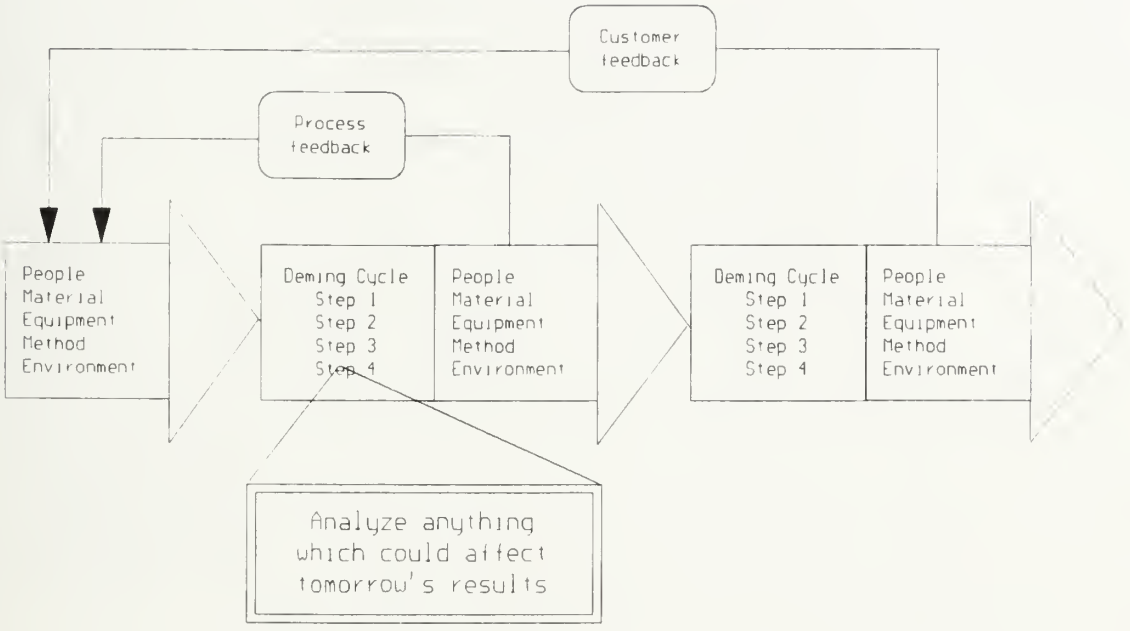

Figure 12 Observe the results.

customer satisfaction and fosters a better understanding of customer requirements.[192] Step 2 is portrayed in figure 11.[193]

Step 3: Observe the results. Analysis of results is best accomplished through statistical methods.[194] But Scherkenbach advises that both quantitative and qualitative

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[192]Ibid.

[193]Ibid.

[194]Ibid.

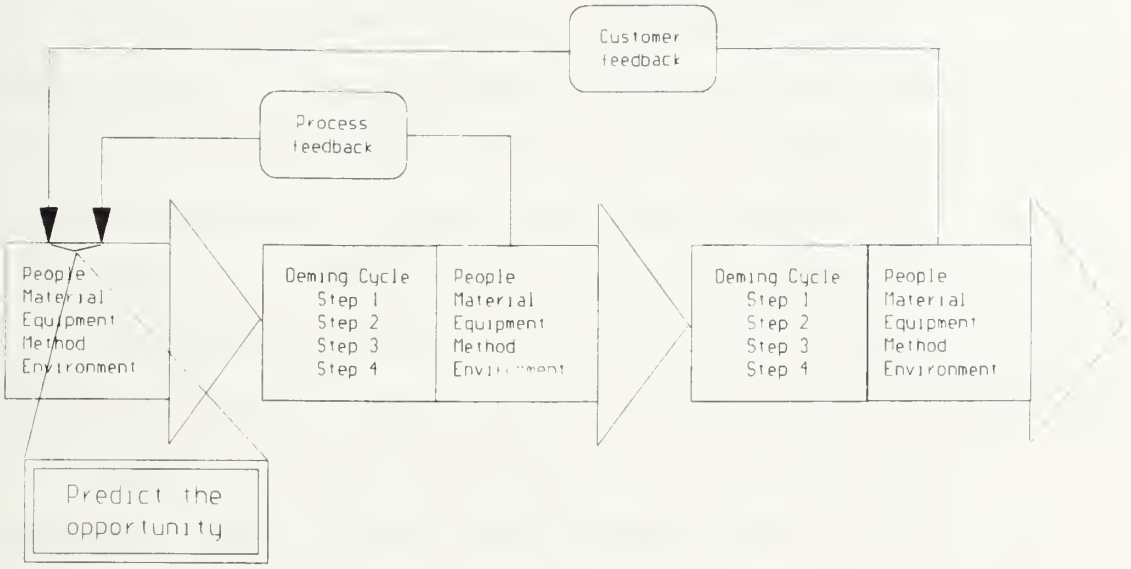

Figure 13 Act on the opportunity.

observation facilitates prediction of "tomorrow's results".[195] Figure 12 shows step 3 in the Deming Cycle.[196]

Step 4: Act on the opportunity. The final step shown in figure 13 is to act on the results of the testing. The predictions made in step 1 are revised based on the

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[195]Ibid.

[196]Ibid., p. 39.

results.[197] The cycle is continually repeated to further improve the process and reduce variability.

Deming says that "putting out fires is not improvement."[198] He contends that finding and removing the cause of a problem does not improve the process but brings it "back to where it was in the first place."[199]

Point 6: Institute training on the job.

Deming asserts that "training must be totally reconstructed."[200] Training and education of employees is a key component of the continuous improvement process. Management must realize "the problems that rob the production worker of the possibility of carrying out his work with satisfaction."[201]

Employee performance can be evaluated using control charts similar to those used in measuring the statistical control of a process.[202] Additional training may not improve employee performance beyond the "stable" condition.[203] This approach is helpful in determining if adequate training has been provided for employees. However, Deming emphasizes the

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[197]Ibid.

[198]Walton, p. 67.

[199]Ibid.

[200]Deming, p. 52.

[201]Ibid.

[202]Walton, p. 68.

[203]Ibid.

need for continued training prior to reaching statistical control of performance and when improvement is still possible.[204]

All employees must gain an understanding of variation and the basic use of control charts.[205] Likewise, the organization must provide training on new equipment and processes.

Point 7: Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.

Deming stresses that "the job of management is not supervision, but leadership."[206] Management must direct efforts toward continuous improvement of the quality of product and service.[207] Deming advises that management should make every effort to remove barriers which deter employees from taking pride in their work.[208]

Scherkenbach suggests that supervisors should perform not only as judge or overseer but also as coach and teacher.[209] He contends that the main responsibility of the supervisor is to develop employees, enhancing their

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[204]Ibid.

[205]Ibid., pp. 68-69.

[206]Deming, p. 54.

[207]Ibid.

[208]Ibid.

[209]Scherkenbach, p. 89.

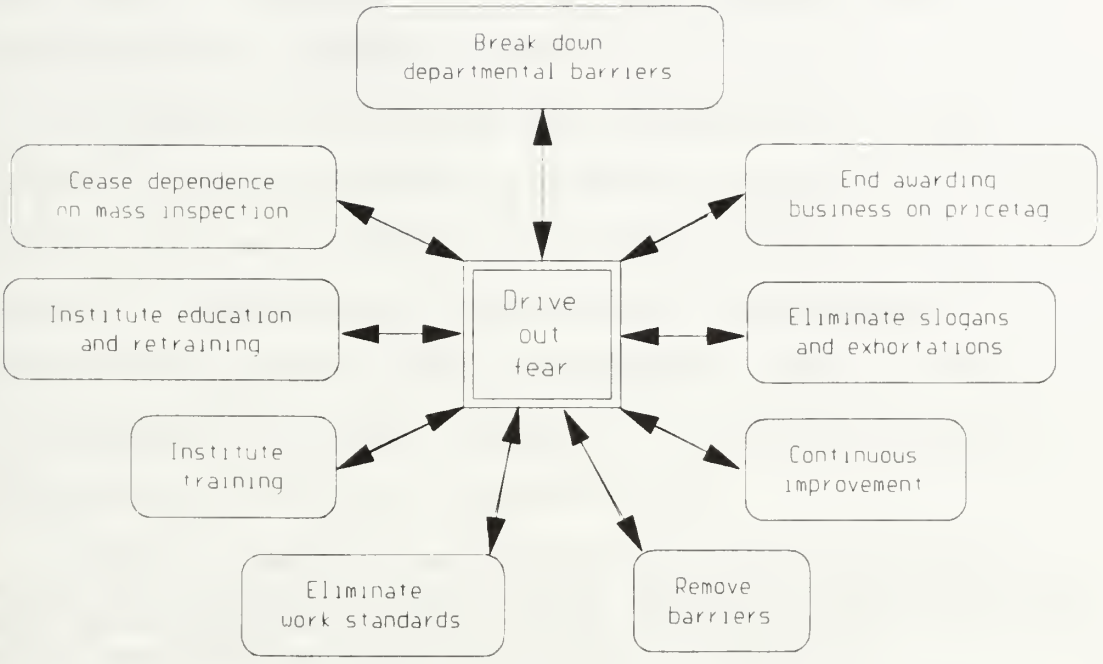

Figure 14 Fear affects nine other points.

performance and assisting in their continuous improvement.[210] Supervision must progress beyond the routine monitoring of "ordinal numbers and percentages."[211]

Point 8: Drive out fear, so that everyone may work effectively for the company.

Deming argues that employees need to feel secure to perform their best work.[212] The word *secure* means "without fear, not afraid to express ideas, not afraid to ask

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[210]Ibid.

[211]Deming, p. 56.

[212]Ibid., p. 59.

questions."[213] Deming claims that fear leads to poor performance and "padded figures".[214]

Management should begin with elimination of fear because of its significant influence on nine of the fourteen points. Figure 14 portrays the affect of fear on the other points.[215] Scherkenbach maintains that the success of statistically based systems of management greatly depends on "an atmosphere of mutual respect."[216] Fear also leads to wasteful activities and increased costs.

Point 9: Break down barriers between departments. People in research, design, sales and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

There are both internal and external customers in a system of continuous improvement. Each member of an organization must gain an understanding of customer needs, both internal and external. Design and sales departments must communicate their requirements to the production department in order to establish mutually attainable goals.[217] Thus, teamwork is an essential element in continual improvement of quality.

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[213]Ibid.

[214]Ibid.

[215]Scherkenbach, p. 75.

[216]Ibid.

[217]Walton, p. 74.

Deming suggests that "teamwork requires one to compensate with his strength someone else's weakness, for everyone to sharpen each other's wits with questions."[218] Teamwork therefore requires a concerted effort by everyone on the team and a willingness to take risks. Without fear of taking a risk, teams could make significant contributions toward improvement of products and services.[219]

Point 10: Eliminate slogans, exhortations and targets for the work force asking for zero defects and new levels of productivity.

Deming claims that slogans do not aid in improving work performance.[220] One slogan states, "Your work is your self-portrait. Would you sign it?" Deming answers, "*No* — not when you give me defective canvas to work with, paint not suited to the job, brushes worn out, so that I can not call it my work."[221] Targets, slogans, and exhortations that promote increased productivity "never helped anyone to do a better job."[222] Slogans like "Zero defects" and "Do it right the first time" are creative, but the problem lies with management failing to provide the work force with the means to these expectations.[223]

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[218]Deming, p. 64.

[219]Ibid.

[220]Walton, p. 76.

[221]Deming, p. 65.

[222]Ibid.

[223]Walton, p. 76.

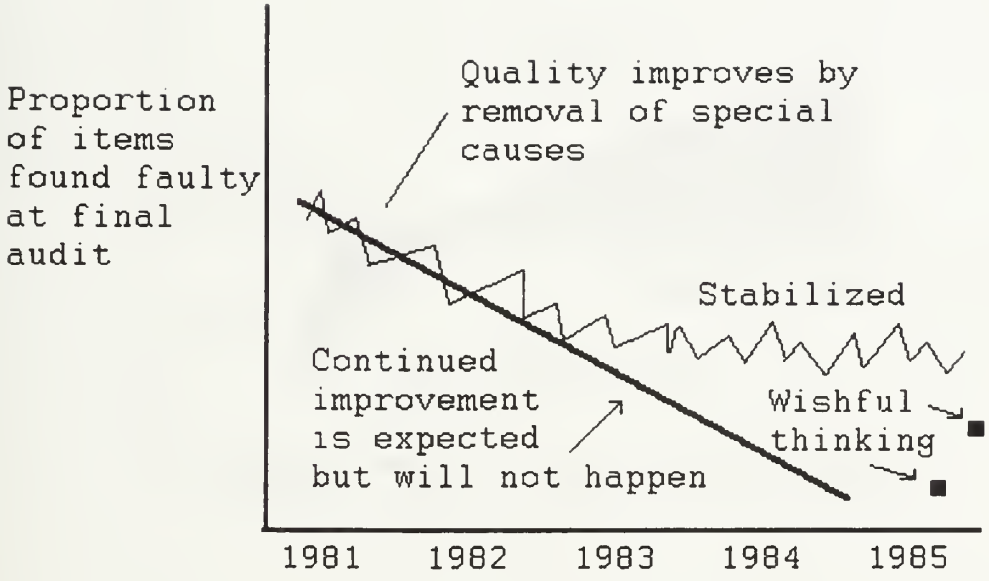

Figure 15 Typical path of frustration.

Scherkenbach stresses that motivation and personal awareness contribute to reducing the variability in a process.[224] But Scherkenbach says that these factors are no substitute for training, knowledge of the process and proper tools and procedures.[225] Management's responsibility is to seek continual improvement of the system and "to remove any special causes detected by statistical methods."[226]

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[224]Scherkenbach, p. 83.

[225]Ibid.

[226]Deming, p. 67.

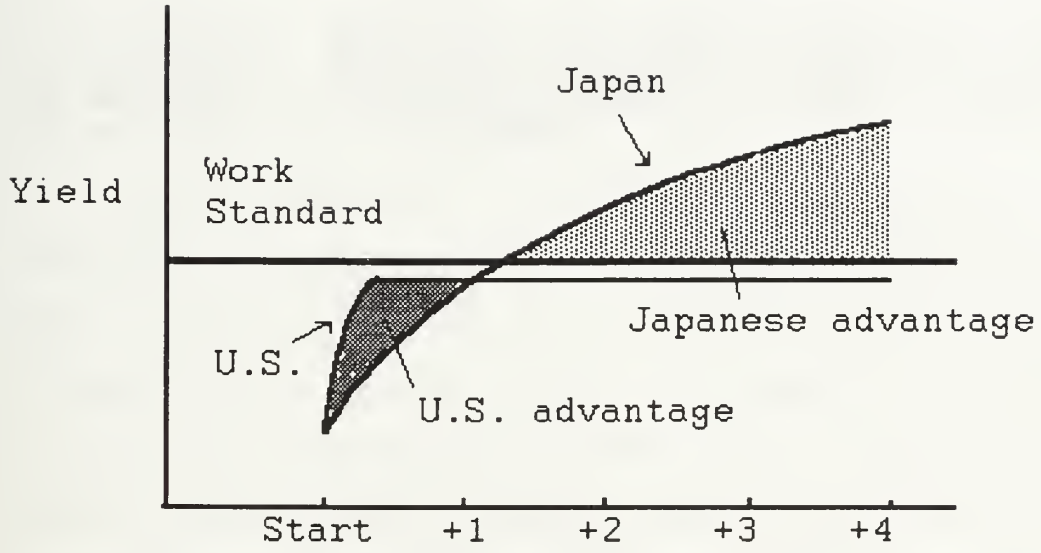

Figure 16 U.S. and Japanese approaches to work standards.

Deming describes "a typical path of frustration" shown in figure 15.[227] The program of quality improvement is based on exhortations, revival meetings, posters and enthusiasm. As quality improves each month, all participants expect continual improvement. But eventually, the curve becomes level, the process becomes stable.[228] Continued improvement

[227]Ibid., p. 323.

[228]Ibid.

is only possible through "removal of special causes" which is the responsibility of management.[229]

Point 11: Eliminate work standards (quotas) on the factory floor. Substitute leadership. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.

Deming says that "a quota is a fortress against improvement of quality and productivity."[230] This concept is hard to apply to the typical U.S. work place where work standards are a common practice. In figure 16, Scherkenbach illustrates the difference between the U.S. approach and the Japanese approach to the production process.[231] The U.S. approach moves promptly to the work standard, immediately producing return on investment; whereas the Japanese take more time to reach the standard, placing emphasis on training, but surpassing the standard as the process continues.[232]

Scherkenbach suggests that the Deming approach, demonstrated by the Japanese, results in more productivity over the life of the process.[233] Similar to engineering tolerances, work standards tend to limit the amount of

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[229]Ibid.

[230]Ibid., p. 71.

[231]Scherkenbach, p. 85.

[232]Ibid.

[233]Ibid., pp. 85-86.

improvement in a system.[234] Efforts toward further improvement are ceased upon reaching the work standard or engineering tolerance.[235]

Scherkenbach says that focusing on outcomes instead of the process restricts the organization's ability to meet customer requirements.[236] Plans are made to meet short-term targets rather than concentrating on long-term customer requirements.[237] Deming stresses that "the job of management is to replace work standards by knowledgeable and intelligent leadership."[238]

Point 12: Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, *inter alia*, abolishment of the annual or merit rating and of management by objective.

Scherkenbach discusses three systems that inhibit continuous improvement.[239] These systems are the Performance Appraisal System, Daily Production Reports and the Financial Management System.

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[234]Ibid., p. 86.

[235]Ibid.

[236]Ibid., p. 88.

[237]Ibid.

[238]Deming, p. 75.

[239]Scherkenbach, pp. 47-74.

Scherkenbach argues that the traditional performance appraisal system inhibits continuous improvement because it frustrates teamwork, encourages mediocrity, increases the variability of performance and concentrates on the short-term.[240] Alternately, a more desirable system of performance appraisal "nurture[s] and sustain[s] individual employee contributions to the continuous improvement of the organization as a team."[241] The appraisal system should recognize that people are an organization's most important asset. The system should foster development and motivation of employees.[242] An appraisal system supporting continuous improvement requires:

> . . . a continuous effort in counseling, coaching and honest, open communications between the employee and the supervisor, supported by opportunities for enhancement of professional, managerial and interpersonal skills.[243]

Scherkenbach recognizes that daily production reports "place undo pressure for sheer quantity."[244] The reports compel managers and supervisors to focus on short-term fixes rather than on long-term solutions.[245] In striving to make

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[240]Ibid., p. 48.

[241]Ibid., p. 57.

[242]Ibid.

[243]Ibid.

[244]Ibid., p. 70.

[245]Ibid.

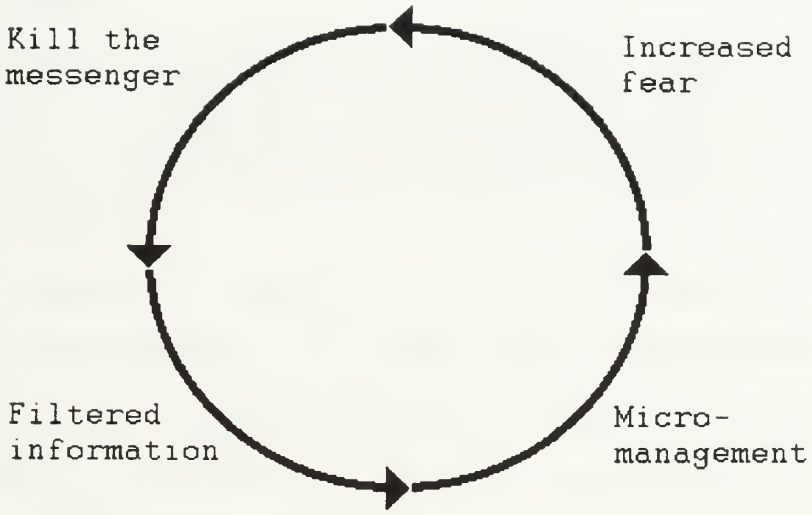

Figure 17 Killing the messenger.

daily quotas, they generate waste and jeopardize quality and productivity.[246]

Scherkenbach suggests that managers and supervisors provide reports to upper management on a weekly basis rather than daily. This procedure empowers the employees by promoting personal development and decision making ability, and minimizes wasted human effort.[247]

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[246]Ibid.

[247]Ibid., pp. 70-71.

Scherkenbach warns of wasteful management practices which isolate managers from important business information. He says that:

> Because of the way they [managers] treated bad news in the past, they will insure that they will only see good news. Through killing the messenger they guarantee that the information passed up to them will be filtered and censored to minimize their fear-inducing reaction.[248]

Because management realizes that the information received is filtered and censored, they react with "micromanagement" and bypass "valuable" middle managers, inducing a fearful atmosphere.[249] Figure 17 illustrates Scherkenbach's thoughts on killing the messenger.[250]

The financial management system inhibits continuous improvement because of the restrictions it places on management.[251] Scherkenbach recommends that managers should have more "flexibility" in managing budget resources and in dealing with specific budget line items.[252]

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[248]Ibid., p. 71.

[249]Ibid.

[250]Ibid.

[251]Ibid.

[252]Ibid.

Point 13: Institute a vigorous program of education and self-improvement.

Deming says that "what an organization needs is not just good people; it needs people that are improving with education."[253] Long-term planning involves "an investment in people" who are constantly increasing their knowledge of new methods and materials.[254] The need for education in statistical methods relative to quality and productivity improvement is becoming increasingly more important.[255]

Point 14: Put everyone in the company to work to accomplish the transformation. The transformation is everybody's job.

Deming describes a plan of action for accomplishing the transformation.[256] "Management in authority" must recognize the advantages of the other thirteen points and define the new direction for the organization.[257] They must adopt the new philosophy, demonstrating pride and commitment. All members of the organization must receive an explanation of the need for change. Deming suggests that "this whole movement may be instituted and carried out by middle management, speaking with one voice."[258]

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[253]Deming, p. 86.

[254]Walton, p. 84.

[255]Ibid.

[256]Deming, pp. 86-92.

[257]Ibid.

[258]Ibid., p. 87.

Deming emphasizes that "every activity, every job is a part of the process."[259] The work is divided into stages through the use of a flow diagram. Every stage has a customer — the next stage.[260] Each stage of the process includes:

> Production — change of state, input changes to output. Something happens to material or papers that come into any stage. They go out in a different state. Continual improvement of method and procedures [occurs], aimed at better satisfaction of the customer (user) at the next stage.[261]

All stages work together toward "optimum accommodation", providing quality products and services for the "ultimate" customer.[262] Each stage is improved through teamwork. Deming says the purpose of a team is "to improve the input and output at any stage."[263] The Deming Cycle (figure 7) will guide the organization in its pursuit of continuous improvement at any stage.

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[259]Ibid.

[260]Ibid.

[261]Ibid.

[262]Ibid.

[263]Ibid., p. 89.

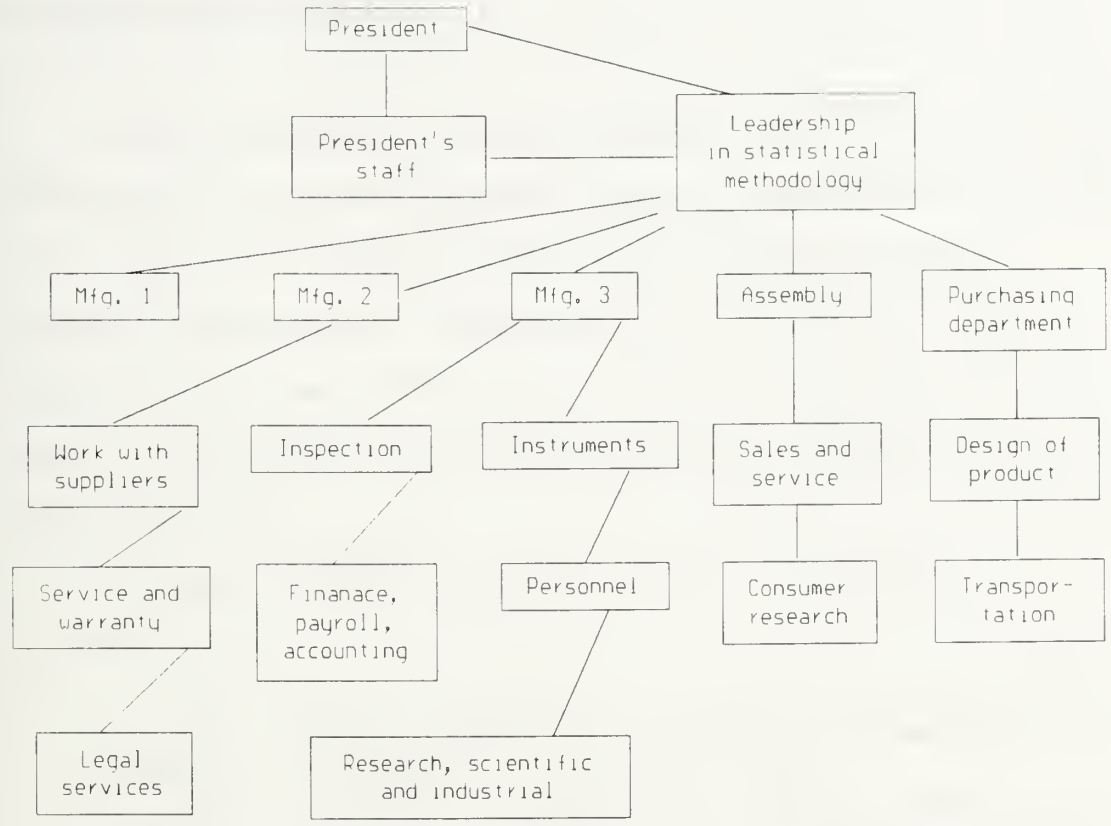

Figure 18 Schematic plan of organization for quality and productivity.

Deming offers a plan for constructing an organization for quality and productivity.[264] Deming's schematic plan shown in figure 18 depicts the principles of organization for quality.[265] This organizational concept is applicable to any type of organization or company. The plan includes a leader of statistical methodology who assists top management in the improvement of processes.

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[264]Ibid., pp. 466-468.

[265]Ibid., p. 467.

DISEASES AND OBSTACLES

Deming identifies deadly diseases that plague American management and hinder progress toward transformation. The most severe ones are referred to as the Seven Deadly Diseases and those of less severity are called Obstacles. Deming states that elimination of these diseases and obstacles requires a "complete shakeup of Western style of management."[266]

Diseases. Deming enumerates the Seven Deadly Diseases:[267]

1. Lack of contancy of purpose to plan product and service that will have a market and keep the company in business, and provide jobs.
2. Emphasis on short-term profits: Short-term thinking (just the opposite from constancy of purpose to stay in business), fed by fear of unfriendly takeover and by push from bankers and owners for dividends.
3. Evaluation of performance, merit rating or annual review.
4. Mobility of management; job-hopping.
5. Management by use only of visible figures, with little or no consideration of figures that are unknown or unknowable.
6. Excessive medical costs.
7. Excessive cost of liability, swelled by lawyers that work on contingency fees.

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[266]Ibid., p. 97.

[267]Ibid., pp. 97-98.

1. Lack of contancy of purpose to plan product and service that will have a market and keep the company in business, and provide jobs.

Walton emphasizes that a company "without constancy of purpose does not think beyond the next quarterly dividend and has no long-range plans for staying in business."[268] Successful organizations must continuously improve products and services, meeting and exceeding customer expectations.

2. Emphasis on short-term profits: Short-term thinking (just the opposite from constancy of purpose to stay in business), fed by fear of unfriendly takeover and by push from bankers and owners for dividends.

Deming says that "pursuit of the quarterly dividend and short-term profit defeat constancy of purpose."[269] He claims that stockholders prefer long-term growth rather than short-term profits.

This emphasis on short-term profits is fed by fear of unfriendly takeover. Deming suggests that "fear of unfriendly takeover may be the single most important obstacle to constancy of purpose."[270] He says the leveraged buyout is "equally devastating".[271]

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[268]Walton, p. 89.

[269]Deming, p. 99.

[270]Ibid., p. 100.

[271]Ibid.

3. Evaluation of performance, merit rating or annual review.

Deming argues that "the performance appraisal or merit rating focuses on the end product, at the end of the stream, not on leadership to help people."[272] Walton further explains that performance appraisals place emphasis on short-term results rather than long-term planning.[273] She says the appraisals "discourage risk-taking, build fear, undermine teamwork and pit people against each other for the same awards."[274]

Deming explains that performance evaluations increase the variability of performance because people with below average ratings try to emulate those with above average ratings.[275]

4. Mobility of management; job-hopping.

Deming quotes J. Noguchi, managing director of the Union of Japanese Scientists and Engineers, who said, "America can not make it because of the mobility of American management."[276] Most Americans will probably disagree that "America can not make it", but there is an apparent benefit of tenured management committed to long-term growth and

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[272]Ibid., p. 102.

[273]Walton, p. 91.

[274]Ibid.

[275]Deming, p. 103.

[276]Ibid., pp. 120-121.

quality improvement. Another serious problem, according to Deming, is the mobility of labor in America resulting from dissatisfaction with the job.[277]

5. Management by use only of visible figures, with little or no consideration of figures that are unknown or unknowable.

Deming asserts that the most important figures are "unknown or unknowable". An example of this point is the effect that a happy customer has on sales or the improvement of quality and productivity from teamwork between employees.[278]

6. Excessive medical costs.

Walton states that medical costs are the largest single expenditure for some companies.[279]

7. Excessive cost of liability, swelled by lawyers that work on contingency fees.

There are usually no real winners in a lawsuit.

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[277]Ibid., p. 121.

[278]Ibid., pp. 121-122.

[279]Walton, p. 93.

Obstacles. There are several obstacles that hinder progress toward improvement of quality and productivity. These obstacles include:[280]

- **The supposition that solving problems, automation, gadgets and new machinery will transform industry.**

- **Search for examples.** Deming says that "improvement of quality is a method, transferable to different problems and circumstances."[281]

- **Our problems are different.** But the principles of quality improvement are applicable to all types of problems.

- **Poor teaching of statistical methods in industry.**

- **Our quality control department takes care of all our problems of quality.** Quality is the responsibility of managers and supervisors as well as production workers.

- **Our troubles lie entirely in the work force.** Walton suggests that "workers are responsible for only 15 percent of the problems, the system for the other 85 percent."[282] She then says that the system is the responsibility of management.[283]

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[280]Deming, pp. 126-148.

[281]Ibid., p. 128.

[282]Walton, p. 94.

[283]Ibid.

- **False starts.** One type of false start is the "wholesale teaching of statistical methods" without an accompanying change in management philosophy.[284] Deming describes another false start, the idea of QC-Circles (Quality Control). He states, "the production worker can tell us a lot about what is wrong and how improvements can be made."[285] But QC-Circles can succeed "only if the management will take action on the recommendation of the Circle."[286]

- **The supposition that it is only necessary to meet specifications.** The true measure of quality is whether or not the product meets customer expectations rather than just meeting specification requirements.

- **Anyone that comes to try to help us must understand all about our business.** Deming explains that "help toward improvement can come only from some other kind of knowledge."[287]

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[284]Deming, p. 136.

[285]Ibid., pp. 136-137.

[286]Ibid., p. 137.

[287]Ibid., p. 143.

QUALITY PRINCIPLES

Mansir and Schacht define principles as "broad statements that provide a framework of general rules to shape organizational thinking."[288] These principles apply to every aspect of the organization. Mansir and Schacht stress that these Continuous Improvement Process (CIP) principles are the foundation for "judging behavior and the basis for assessing corporate culture."[289]

The principles of continuous improvement mirror Deming's management concepts. These principles include (1) constancy of purpose, (2) commitment to quality, (3) customer focus and involvement, (4) process orientation, (5) continuous improvement, (6) system-centered management, (7) investment in knowledge, (8) teamwork, (9) conservation of human resources, (10) total involvement and (11) perpetual commitment.[290] Figure 19 shows how "the principles work together in a logical and holistic manner to give substance and vitality to the continuously improving culture."[291]

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[288]Mansir and Schacht, p. 3-1.

[289]Ibid.

[290]Ibid., pp. 3-1 - 3-27.

[291]Ibid., pp. 3-1 - 3-2.

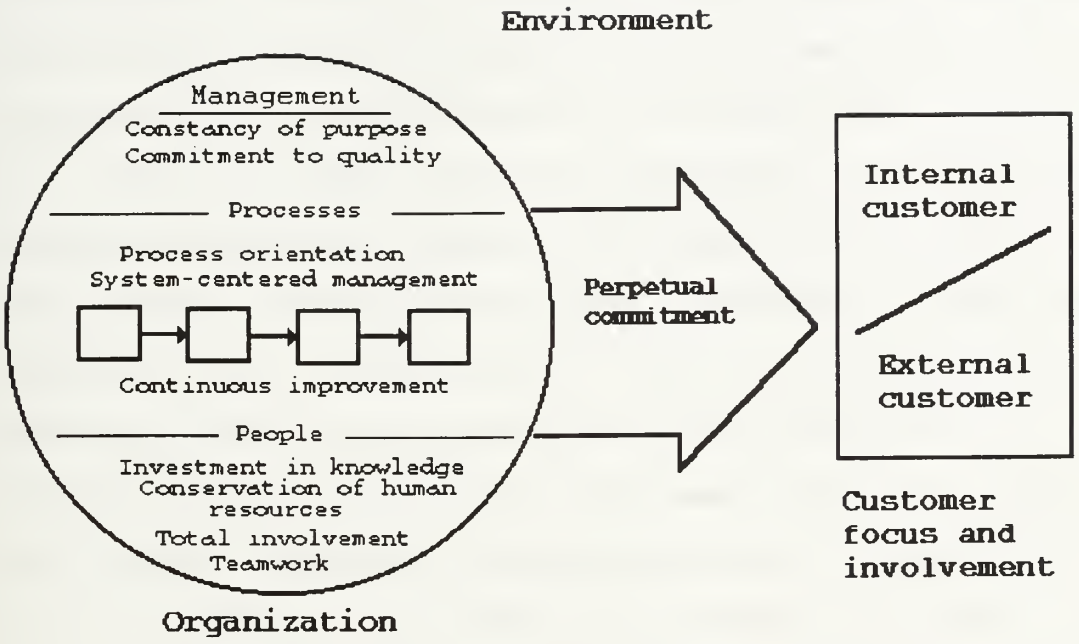

Figure 19 Mansir and Schacht's holistic CIP view.

First, the constancy of purpose principle is centered on top management's statement of organizational purpose. The "vision of the organization" provides consistent goals and objectives supported by sound strategic and tactical plans.[292]

[292]Ibid., p. 3-4.

Second, the basis for continuous improvement is commitment to quality. Quality in this context must range in definition from "conforming to specifications" to "an intangible but perceived inherent goodness."[293]

Third, customer focus and involvement is essential for process improvement. Mansir and Schacht assert that "attracting, serving and retaining customers is the ultimate purpose of any organization."[294] They say that "those customers help the organization frame its quality consciousness and guide its improvement effort."[295] Scholtes distinguishes between internal and external customers.[296] External customers are those who purchase or use the organization's products or services whereas internal customers are "fellow employees whose work depends on the work that precedes them."[297]

Fourth, the most effective means to address customer expectations is to focus on process improvement. Where traditional management methods focus on post-production inspection and rejection of defective products, the Continuous Improvement Process forces management to focus on

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[293]Ibid., p. 3-5.

[294]Ibid., p. 3-7.

[295]Ibid.

[296]Scholtes, p. 1-11.

[297]Ibid.

the process.[298] This process oriented approach deals with the collection, timing, feedback and management response to measurement data.

Fifth, the fundamental principle of the CIP is continuous improvement.[299] The key to continuous improvement is integrating both innovative and small incremental changes to the process. Innovation in the form of new technologies or new ways of thinking is characterized by large changes and dramatic improvement of performance, while frequent small changes result in steady process improvement.[300]

Sixth, system-centered management requires managers to constantly improve the system by which work is accomplished.[301] The traditional approach was to accomplish work according to set procedures and established processes, failing to make system-centered improvements.

Seventh, investment in knowledge emphasizes improvement of human potential and growth. Personal knowledge, teamwork, security and personal involvement are expanded by increased education and training. Through improved job skills and abilities, and better understanding of the work

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[298]Mansir and Schacht, pp. 3-8 - 3-9.

[299]Ibid., p. 3-10.

[300]Ibid., p. 3-11.

[301]Ibid., p. 3-14.

process, employees will become better able to recognize and eliminate problems.[302]

Eighth, teamwork is essential to the success of continuous improvement in an organization. Process improvement teams are developed throughout the organization, translating specific goals and objectives into action. Teamwork applies to all levels in the organizational structure. Scholtes emphasizes that "the notion of a common struggle for quality also applies to relationships with suppliers, regulating agencies and local communities."[303]

Ninth, the principle of conservation of human resources recognizes that people are an organization's most important asset.[304] Management creates a working environment in which employees are encouraged to suggest better ways to accomplish work. Management stimulates, recognizes and awards contributions of all its people.

Tenth, the principle of total involvement ensures that every member of the organization participates in continuous improvement both at the individual and team levels.[305] The employees are given the authority to make decisions and initiate improvement actions within their own work areas.

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[302]Ibid., p. 3-17.

[303]Scholtes, p. 1-13.

[304]Mansir and Schacht, p. 3-20.

[305]Ibid., p. 3-22.

Management respects and trusts employees to exercise self-discipline and self-direction.

Lastly, perpetual commitment ensures that continuous improvement is a steady, long-term effort. Management has the responsibility to "encourage and facilitate positive change" and support creative improvement initiatives of the work force.[306] Each member of the organization must recognize a personal role and make a commitment to continuous improvement.

Robert D. Martin, the chairman of Martin Paving Company, says that Total Quality Management has four basic principles. He calls these principles the "Four Cs of Quality":[307]

- Commitment to error free work.
- Continuous improvement.
- Concentration on prevention.
- Customer knowledge.

Martin attests that Total Quality Management (TQM) differs from traditional quality assurance programs in several ways. Martin says "the TQM definition of quality is more customer oriented than product oriented."[308] At Martin Paving Co., quality has a higher priority than cost, schedule and even safety.[309] TQM companies make decisions

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[306]Ibid., p. 3-25.

[307]Robert D. Martin, "'Total quality' Boosts Performance," Roads and Bridges, July 1992, p. 19.

[308]Ibid.

[309]Ibid.

based on long-term goals rather than short-term objectives.[310] Martin's approach focuses on improving the process and satisfying the customer rather than evaluating whether they can place a certain tonnage of asphalt per day.[311] TQM focuses on the prevention of errors and continuous improvement where traditional quality assurance programs concentrate on the detection of errors.[312] Martin claims that productivity increases and costs decrease in a TQM environment.[313]

The TQM approach involves all employees in the quality process whereas a typical quality assurance program places the responsibility of quality only on quality assurance inspectors.[314] Martin suggests that "the concept of TQM contributes to continuous improvement, innovation and risk taking throughout the corporation."[315] He asserts that quality assurance programs promote "fingerpointing, blame finding, punishing risk takers and shooting the messenger."[316]

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[310]Ibid.

[311]Ibid.

[312]Ibid.

[313]Ibid.

[314]Ibid.

[315]Ibid.

[316]Ibid.

Martin advocates a TQM company that is "fluid and integrated" with a flat organizational structure.[317] He says a quality assurance organization "tends to be hierarchical, bureaucratic and static."[318] The TQM approach involves all employees in problem solving and recognizes them for their efforts. Martin claims that problem solving is performed only by senior management under the traditional approach.[319] Open communication is encouraged at the Martin Paving Co. Martin says that "information is shared with the workers for use in their quality improvement teams."[320]

Martin challenges the construction industry to adopt the TQM approach. He maintains that "constructors are 15 times more likely to prefer to work independently, resulting in lower quality work, higher costs and more litigation."[321] He firmly believes that the TQM approach will result in more profits, reduced costs, enhanced safety and "a better reputation for the construction industry as a whole."[322] He says that "quality assurance programs are just not enough" to ensure continuous improvement.[323]

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[317]Ibid.

[318]Ibid.

[319]Ibid.

[320]Ibid.

[321]Ibid.

[322]Ibid.

[323]Ibid.

CHAPTER 3
TOTAL QUALITY MANAGEMENT IMPLEMENTATION

QUALITY IN CONSTRUCTION

The American Society of Civil Engineer's *Guide to Quality in the Constructed Project* describes the principles and procedures for achieving quality in the constructed project.[324] The suggestions and recommendations in the guide parallel the principles of Total Quality Management.

The guide defines quality in the constructed project as:

> . . . meeting the requirements of the owner, design professional and the constructor as specified in the contract, while complying with laws, codes, standards, regulatory rules and other matters of public policy.[325]

The guide includes the regulatory agency as a "partner" along with the three other participants.[326] The quality in the constructed project is attained through teamwork among the participants, working together to achieve mutual goals.

The guide describes specific responsibilities of each team member. The owner is responsible for project definition and organization, for financial and site acquisition arrangements, for administration of contracts

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[324]American Society of Civil Engineers, Quality in the Constructed Project (New York: American Society of Civil Engineers, 1990), p. xxi.

[325]Ibid.

[326]Ibid.

and for operation and maintenance of the completed facility.[327] The design professional is responsible for planning and design, preparation of the construction contract, and construction observation and technical review of submittals prepared by the constructor.[328] The constructor is responsible for construction of the project facilities as specified in the contract, for job-site safety and for protection of public health, safety and the environment.[329]

The guide suggests that "quality in the constructed project results when the state of mind of those involved in the project places quality foremost."[330] Effective communication and mutual understanding between participants are essential for attainment of quality. All participants must make a determined effort to resolve the problems that are routinely encountered during the construction process.[331]

There are several themes presented in the guide that are important to the quality process. The principal themes include the definition and assignment of responsibilities, importance of teamwork, understanding requirements and expectations, principles of good communication, owner's

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[327]Ibid., p. xxiv.

[328]Ibid.

[329]Ibid.

[330]Ibid., p. xxv.

[331]Ibid.

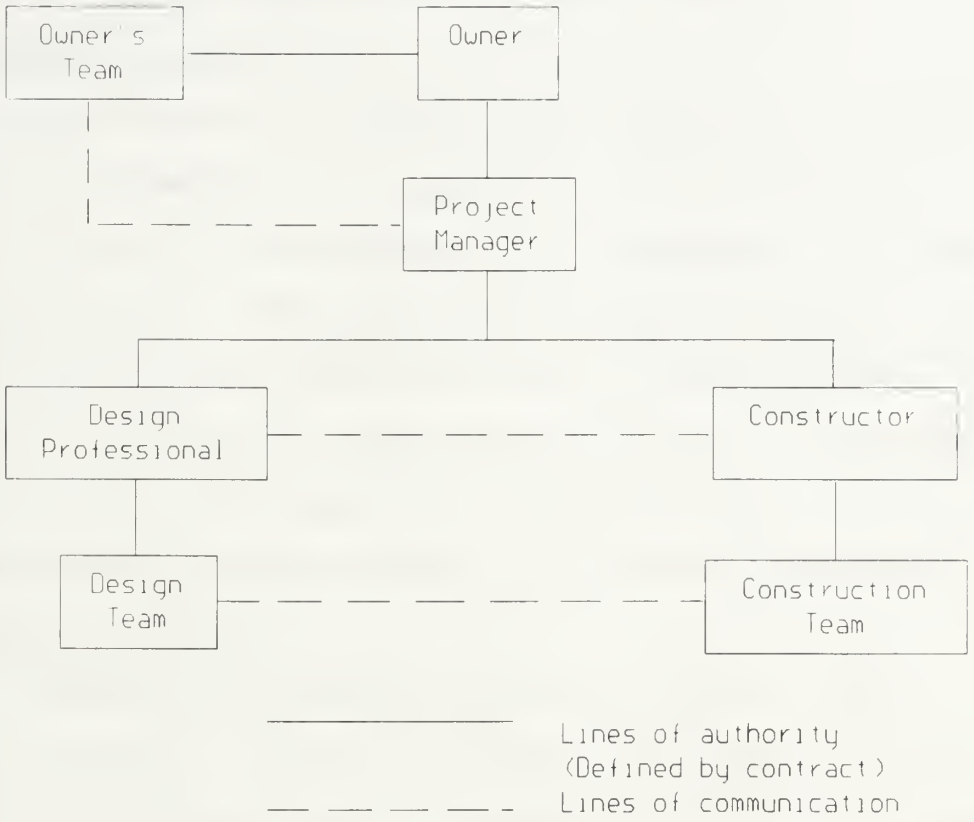

Figure 20 Project team organization.

selection processes for project team members and other important factors which contribute to quality in the constructed project.[332]

The guide discusses two significant factors that contribute to achieving quality. First, the owner develops "complete and realistic expectations and requirements for the project."[333] Second, the team members must acquire a

[332]Ibid., p. 1.

[333]Ibid., p. 5.

thorough understanding of the owner's role and responsibilities.[334]

The construction project team consists of an owner, design professional and constructor, each competently fulfilling their obligations in an atmosphere of "harmonious cooperation".[335] The owner monitors and coordinates the activities of the other participants throughout the planning, design and construction process.[336] The guide suggests that "the owner may discharge these responsibilities more effectively by delegating authority to a project manager."[337]

Figure 20 illustrates the typical project team organization.[338] The guide stresses that there are other successful organizational arrangements such as the design-construct firm which performs both design and construction work under one contract.

Effective coordination and communication are essential elements in the quality construction process. The guide states "coordination translates to effective implementation."[339] It also emphasizes the need for

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[334]Ibid.

[335]Ibid., p. 12.

[336]Ibid., p. 13.

[337]Ibid.

[338]Ibid., p. 9.

[339]Ibid., p. 14.

Participant	Project Beginning	Design Phase	Construction Phase	Project Completion
Owner	Forming and informing the group. Leading in outlining project requirements for the design professional.	Contributing to decisions in support of design reviews. Participating in design reviews. Communicating changes when necessary.	Providing for qualified inspection and testing as required by contract documents and regulatory agencies. Administering contracts.	Maintaining group coordination and getting the group's attention on follow-up or completion items.
Design Professional	Assisting with project objectives and program requirements. Leading the development of process for coordination among team members.	Leading the design effort. Involving the owner and others at appropriate times. Preparing necessary design plans and specifications.	Technical support for required interpretations, changes, shop drawings, reviews or field problems, in a timely way. Field observation.	Assisting with follow-up work, completing required manuals and documents, assisting with start-up.
Constructor	Being an early participant. Contributing to alternative studies and scheduling.	Assisting in vender selection and constructability reviews.	Performing the construction effort. Involving others at appropriate times, such as shop drawings, inspections, tests, etc. Field observation.	Leading the follow-up. Guiding vendor and subcontractor follow-up work.

Table 1 Roles of project team members.

commitment by team members to facilitate good communication.[340] Table 1 describes the principal roles of each team member in coordination as the project progresses from start to completion.[341]

The guide recommends that owners follow the procedures used by federal and state agencies, specified in the Brooks

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[340]Ibid.

[341]Ibid., p. 15.

and mini-Brooks laws, in their procurement of professional design services.[342] Responding to an owner's invitation and statement of requirements for a specific project, the design professional submits statements of interest and qualifications. The owner evaluates the responses according to criteria included in the invitation. Selection of the design professional is made after the owner conducts personal interviews with the most qualified applicants. Contract negotiations between the owner and the design professional are conducted to define the scope of services, schedule and compensation plan.

The selection process allows the owner not only to select the most suitable design professional but also provides the opportunity to establish a cooperative relationship between the two parties. The procedures provide the groundwork for developing a long-term relationship similar to the single supplier relationship advocated by Deming.

The team approach to the construction process is applicable at the project conceptualization and planning stage. The owner, design professional and constructor (if available) jointly participate in formulating, investigating and studying alternative approaches to execution of the project.[343] These alternative studies include a variety of

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[342]Ibid., p. 22.

[343]Ibid., p. 27.

processes relating to such items as site selection, schedule, materials and equipment.[344] The physical, economic and social implications of the project are also analyzed in this joint effort.[345]

The guide advises that the design professional can avoid "threats to quality" by:[346]

- Developing the scope of services to meet project requirements.
- Developing the work plan for the design phase of the project.
- Estimating accurately the hours of effort required and cost involved to achieve a quality design.
- Recognizing that most programs are incomplete, that changes are inevitable and that budgets and schedules usually need to be revised accordingly.
- Developing a realistic schedule.

The guide emphasizes the importance of including associate consultants in the development of the scope of services.[347] Likewise, it cautions against the use of competitive bidding in obtaining professional services because making a selection without proper consideration of qualifications and scope will severely threaten quality.[348] Avoiding threats to quality includes the assignment of experienced and knowledgeable personnel to the design team

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[344]Ibid.

[345]Ibid.

[346]Ibid., p. 33.

[347]Ibid.

[348]Ibid.

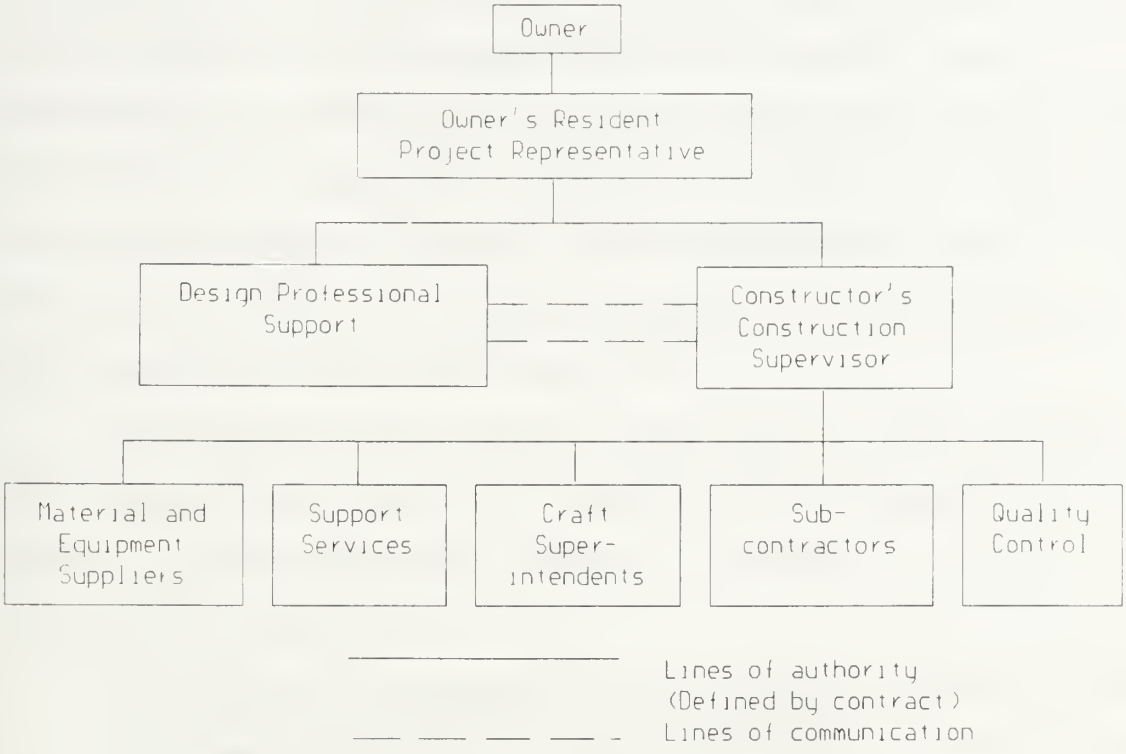

Figure 21 Field organization for construction.

as well as information-gathering and field survey teams.[349] The importance of training and education is evident in performing design functions that enhance the quality objectives of the project team.

The owner is responsible for assembling a construction team for field operations that complements the project team organization.[350] The construction team must have the capability to build a quality facility while complying with

[349]Ibid

[350]Ibid., p. 51.

appropriate safety, schedule and budget requirements.[351] The owner's resident project representative provides team leadership and direction in the day-to-day administration of the design and construction contracts.[352] Figure 21 shows the organization of a typical field construction team.[353] The guide attests that "quality depends on the competence and integrity of each team member."[354]

The guide describes specific responsibilities of each team member that "cannot be altered without threatening quality in the constructed project."[355] These responsibilities are:[356]

- The owner is responsible for contract enforcement and stopping work (except in emergencies).
- The design professional is responsible for design and design changes and interpretation of design requirements.
- The constructor is responsible for construction means, methods, sequences, direction of work, job safety and completing the project construction to a level of quality in accordance with the requirements of the contract documents.

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[351]Ibid.

[352]Ibid., p. 54.

[353]Ibid., p. 52.

[354]Ibid., p. 54.

[355]Ibid., p. 65.

[356]Ibid.

The owner's resident project representative implements procedures for reviewing and evaluating the quality of construction.[357] In situ (natural or original) materials and procured materials are evaluated to determine if they meet acceptable quality standards. Laboratory testing and engineering evaluation are often required for in situ materials.

The specifications outline the minimum quality standards and qualification methods for procured materials such as structural steel, asphalt, concrete, paint and mechanical and electrical equipment. There are also several organizations such as the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) which provide information on qualification and acceptance standards for a variety of materials and products.

The guide states that practices for determining minimum levels of acceptance for workmanship are more subjective in many instances.[358] For example, structural requirements like soil compaction or tightness of bolts are well defined, but the acceptability of concrete wall finish requires more "subjective judgements".[359]

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[357]Ibid., p. 71.

[358]Ibid., p. 72.

[359]Ibid.

The guide discusses the "trend in the construction industry toward statistical analysis for quality control by constructors and suppliers, and for statistically based acceptance criteria by owning agencies."[360] It states that the American Concrete Institute (ACI) provides details on statistically based acceptance procedures for concrete and that reports on statistically based specifications are available from the Transportation Research Board.[361] This increased emphasis on statistical methods complements Deming's view that statistical process control is essential to the quality transformation of Western organizations.

There are several definitions of Quality Assurance and Quality Control. The guide defines these functions as follows:[362]

- Quality Assurance (QA) comprises all those planned and systematic actions necessary to provide confidence that items are designed and constructed in accordance with applicable standards and as specified by contract.

- Quality Control (QC) comprises the examination of services provided and work done, together with management and documentation necessary to demonstrate that these services and work meet contractual and regulatory requirements.

Thus, these functions comprise a comprehensive effort to successfully attain quality in contracting. Total Quality

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[360]Ibid.

[361]Ibid.

[362]Ibid., p. 84.

Management, however, includes not only Quality Assurance and Quality Control but also Customer Focus and more:

Total Quality Management = Quality Assurance + Quality Control + Customer Focus + More

The Naval Facilities Engineering Command Contracting Manual (P-68) views the process differently than *Guide to Quality in the Constructed Project*. The manual defines Quality Control as "the contractor's management and control of his own, his suppliers', and his subcontractors' activities to comply with contract requirements."[363] The Contracting Manual further defines Quality Assurance as "the means by which the Government fulfills its responsibility in assuring that the contractor's Quality Control system is functioning and through reviews, surveillance and testing assures the completed product complies with the contract."[364] Quality Management is defined by the Contracting Manual as "all control and assurance activities to achieve that quality which is established by the contract."[365]

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[363]Contracting Manual, NAVFAC P-68, Change 87-02 (Alexandria, Virginia: Naval Facilities Engineering Command, Department of the Navy, 1987), p. 176.

[364]Ibid.

[365]Ibid.

Therefore, quality is defined in the realm of Government contract administration as the degree at which the physical condition of the end product conforms to the requirements set forth in the contract plans and specifications. Quality Assurance is the process of confirming that the product conforms to the contract plans and specifications. Objective Quality Assurance methods consisting of measurable criteria are used in evaluation of performance. Quality Assurance is the sole responsibility of the Government and is not a substitute for Quality Control.

Quality Control is the process in which the contractor ensures that the product conforms with the specifications. The contractor also provides acceptable and competent workmanship, proper equipment and materials, and timely services. The contractor is responsible for providing and maintaining an adequate inspection system and maintaining complete and accurate records of all completed inspection work. The responsibility of quality is therefore fixed on the contractor.

Quality is defined differently depending on your perspective. If a product conforms to the producer's specifications, the quality of the product is considered "quality-in-fact".[366] On the other hand, if the products and

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[366]Facility Support Contract Quality Management Manual, MO-327 (Alexandria, Virginia: Naval Facilities Engineering Command, Department of the Navy, 1989), p. 3.

services meet the customer's expectations, the quality is considered "quality-in-perception".[367] Therefore, true quality is achieved when the product not only complies with specifications, quality-in-fact, but also meets the customer's expectations, quality-in-perception.

The Government definition of Quality Management above endeavors to achieve a quality-in-fact product or output. But successful Quality Management depends on attainment of both quality-in-fact and quality-in-perception. True quality is only attained when the specifications reflect as closely as possible the quality expectations perceived by the customer. Thus, effective Quality Management goes beyond achieving the quality established by the contract. The effort not only includes control and assurance activities to achieve the quality specified in the contract but also a dedicated Customer Focus on meeting and exceeding customer expectations. The process is referred to as Total Quality Management because it is based on a total commitment by every member of the organization in addition to Quality Assurance and Quality Control activities and a dedicated Customer Focus.

The *Guide to Quality in the Constructed Project* indicates that the owner, assisted by the design professional, develops the Quality Assurance and Quality Control program requirements during the early stages of the

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[367]Ibid.

project.[368] The design professional prepares and implements the program during the design phase.[369] The design professional employs quality management procedures "to improve thought processes, clarify communications among team members and to transfer the concepts and mental images of the project . . . to physical structures and systems to be built by the constructor."[370] The constructor's role is to comply with contract quality requirements during the construction phase of the project. The guide stresses that quality depends on total commitment and mutual understanding by all the team members.

Donald S. Barrie and Boyd C. Paulson discuss another view of the quality process. They describe Quality Engineering as:

> . . . procedures used to ensure that the engineering and design for a structure proceed according to recommended and mandatory criteria set by related professional and trade associations, building code authorities and federal, state and local organizations such as the Environmental Protection Agency, the Nuclear Regulatory Commission, the Occupational Safety and Health Administration and others.[371]

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[368]American Society of Civil Engineers, p. 84.

[369]Ibid.

[370]Ibid.

[371]Donald S. Barrie and Boyd C. Paulson, Jr., Professional Construction Management (New York: McGraw-Hill, Inc., 1992), p. 372.

The process of Quality Control includes:[372]

- Setting specific standards for construction performance, usually through plans and specifications.
- Measuring variances from the standards.
- Taking action to correct or minimize adverse variances.
- Planning for improvements in the standards themselves and in conformance with the standards.

Barrie and Paulson explain that the definition of Quality Assurance is not "well standardized"[373] They say that Quality Assurance broadly encompasses "the application of standards and procedures to ensure that a product or a facility meets or exceeds desired performance criteria."[374]

Barrie and Paulson suggest that the "basic elements of quality" include quality *characteristics*, quality of *design* and quality of *conformance*.[375] Figure 22 shows the relationship between these elements of quality.[376]

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[372]Ibid.

[373]Ibid.

[374]Ibid.

[375]Ibid.

[376]Ibid., p. 374.

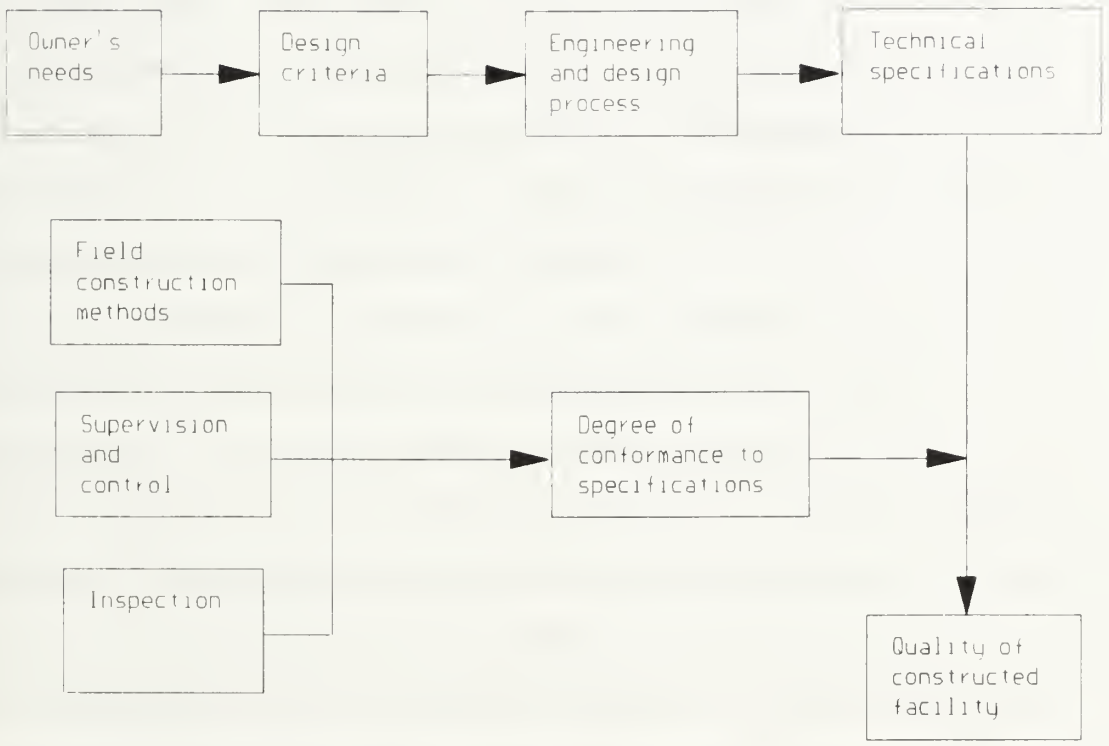

Figure 22 Basic elements of quality.

Quality characteristics are "properties that define the nature of a product for quality control purposes" such as dimension, color, strength or temperature.[377] The owners needs and specified quality characteristics are delineated by the design criteria used in the engineering and design process for development of the technical specifications. The quality of design is a function of this process. The quality of design involves the tolerances or ranges for acceptable variation from the standard specified for the

[377]Ibid., p. 372.

product.[378] The designer must evaluate the impact on initial cost of higher standards of quality or less variation as well as the effect on life cycle costs of using inferior materials or allowing more variation. The quality of conformance is the extent to which the construction effort complies with the specified standard.[379]

The Partnering process is a new concept in the construction industry that compliments Total Quality Management. Partnering involves the members of the construction team in the development of a strategy for the purpose of avoiding disputes, fostering a cooperative spirit and facilitating successful completion of the project. The key elements to the Partnering concept include commitment, equity, trust, development of mutual goals and objectives, implementation of the mutual goals, continuous evaluation and timely responsiveness.[380]

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[378]Ibid., p. 373.

[379]Ibid.

[380]The Associated General Contractors of America, Partnering: A Concept for Success (Washington, D.C.: The Associated General Contractors of America, 1991), p. 2.

QUALITY CONTROL TECHNIQUES

The are several types of charts that are useful for presenting data and understanding processes. These charts include the cause-and-effect diagram, flow chart, Pareto chart, run (trend) chart, histogram, control chart and scatter diagram. Diane Ritter's depiction of these useful charts is shown in figure 23.[381]

The cause-and-effect diagram is useful in problem solving. The causes are often grouped into major categories such as **Method, Manpower, Material** and **Machinery.** The possible causes in each category are explored to determine the most significant causes which produce the effect. Figure 24 shows a typical cause-and effect diagram.

Kaoru Ishikawa describes cause-and-effect diagrams as an effective tool "to clearly illustrate the various causes affecting quality by sorting out and relating causes."[382] For example, figure 25 shows the cause-and-effect diagram for wobbling during machine rotation.[383] The main line of the diagram follows the production process and everything that affects the quality is included at each step in the process.

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[381]Walton, p. 98.

[382]Kaoru Ishikawa, Guide to Quality Control (White Plains, New York: Asian Productivity Organization, 1982), p. 25.

[383]Ibid., p. 23.

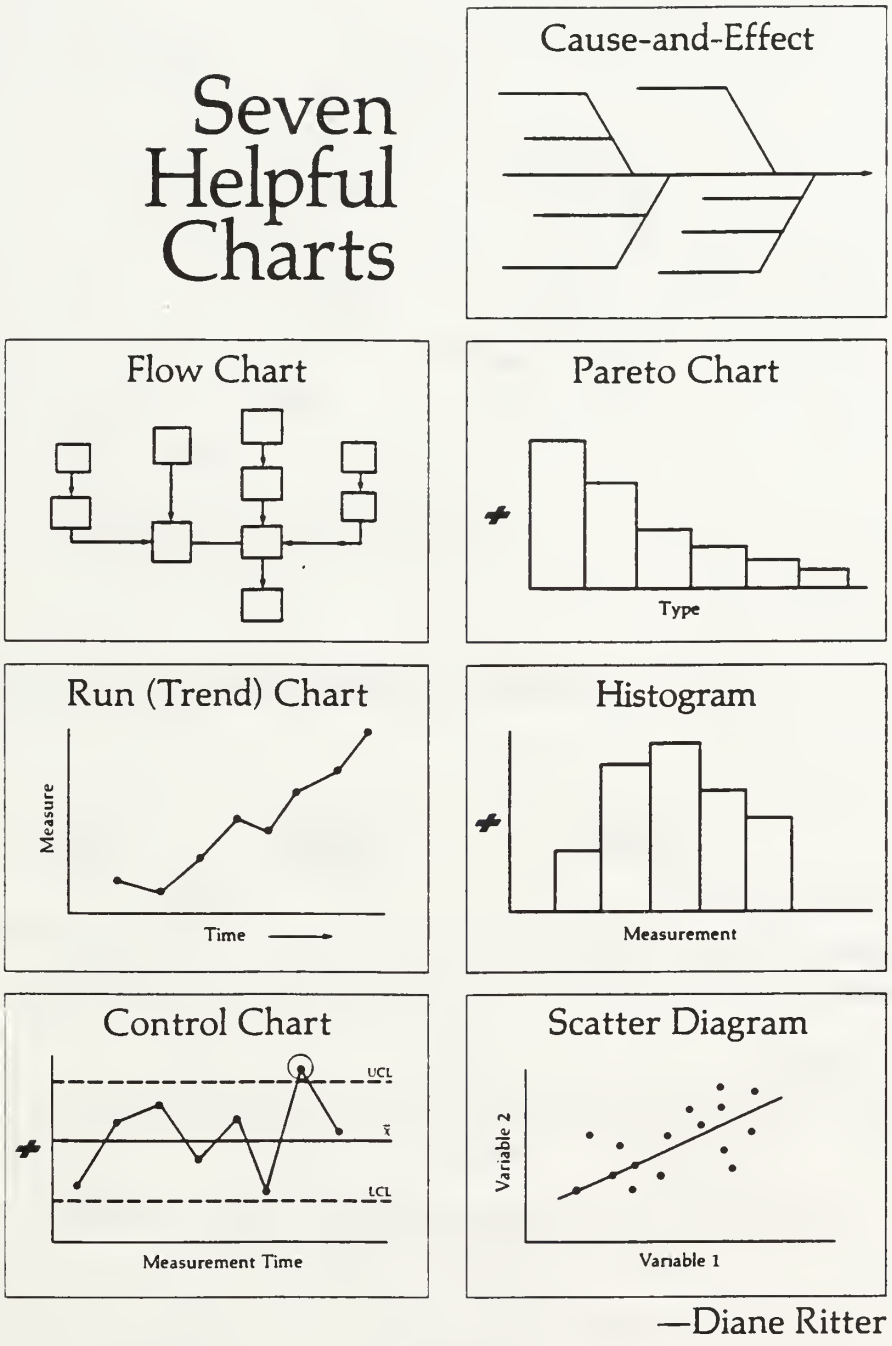

Figure 23 Useful charts for presenting data and understanding processes.

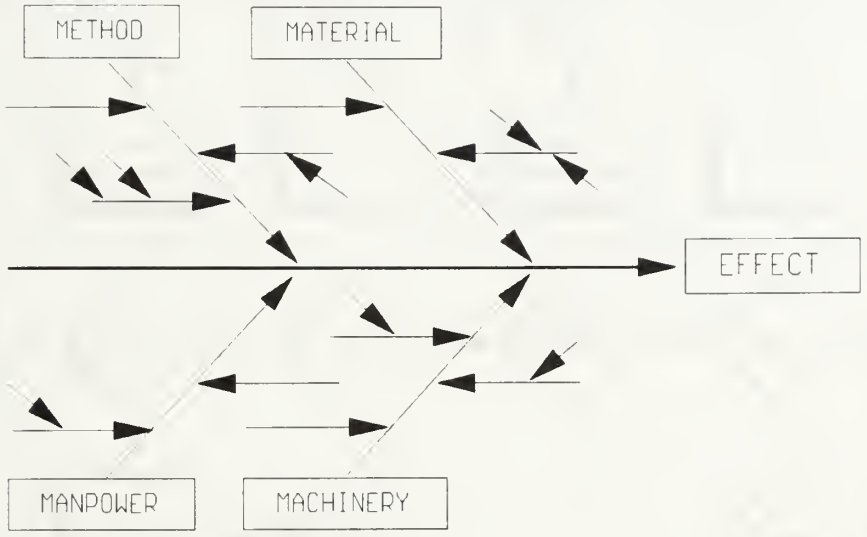

Figure 24 Cause-and-effect diagram.

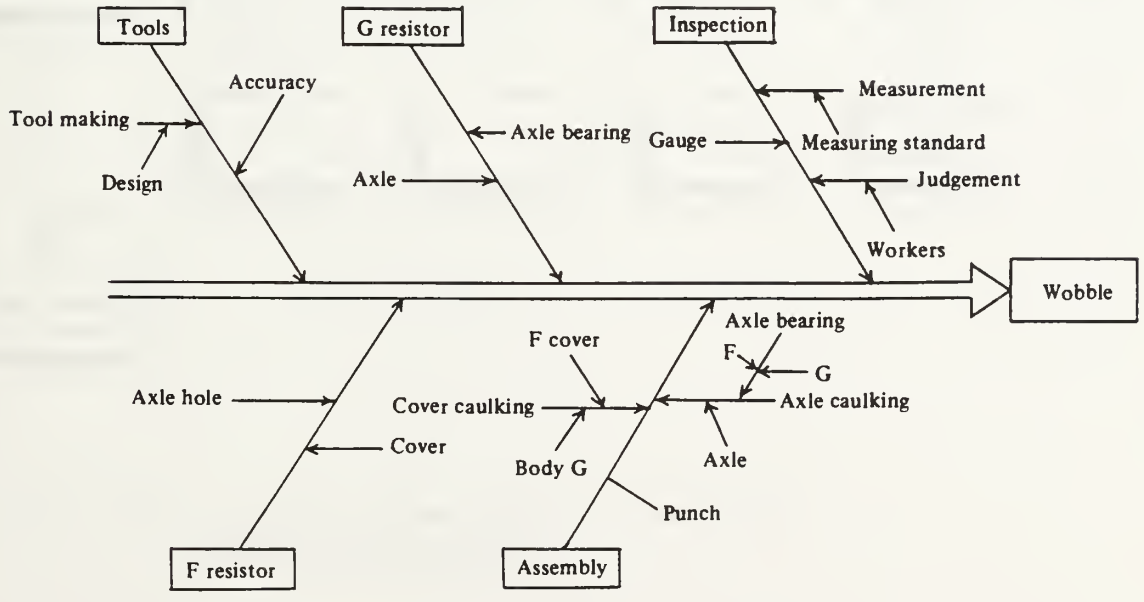

Figure 25 Cause-and-effect diagram for wobbling.

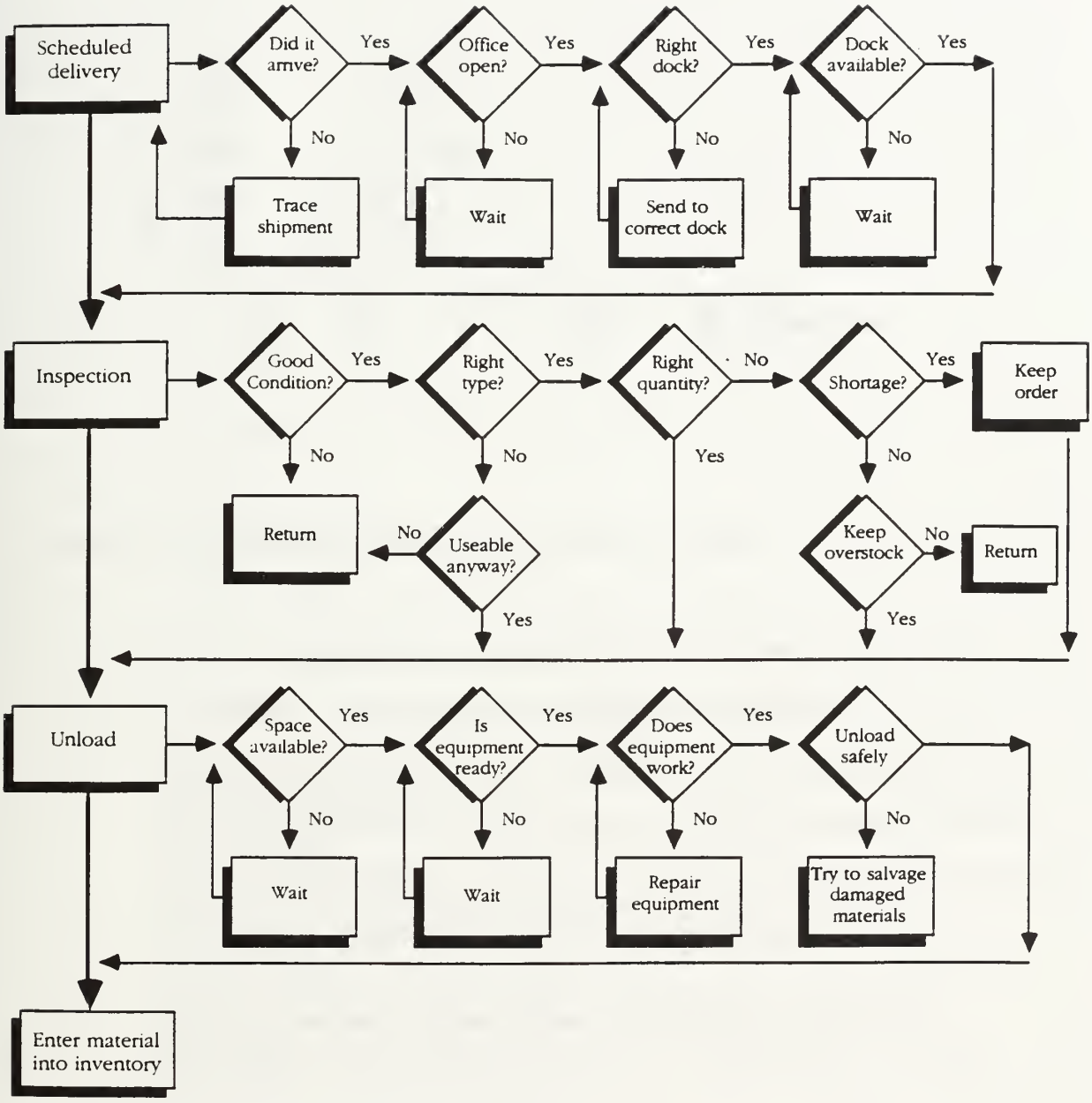

Figure 26 Detailed flow chart of supplies receiving process.

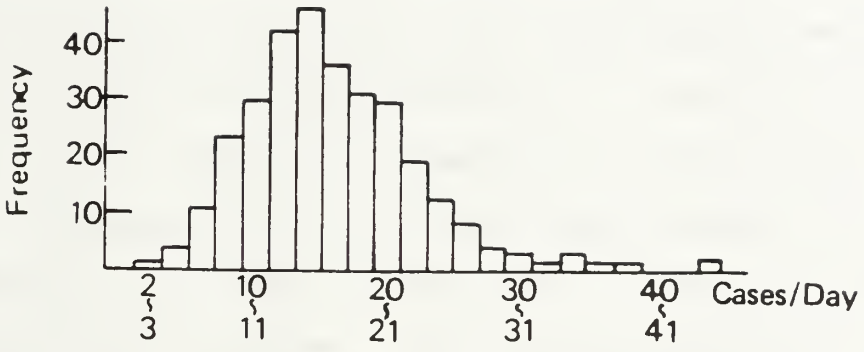

Figure 27 Failure occurrence distribution.

Ishikawa discusses the benefits of using cause-and-effect diagrams. The primary benefits include:[384]

- The preparation of the diagrams are educational for all the participants.
- The diagrams help the group to focus on the topic of discussion.
- The process results in an active investigation of the causes of the quality characteristic.
- The cause-and-effect diagram requires data collection.
- The "level of technology" of the workers is demonstrated by the cause-and-effect diagrams.
- The cause-and-effect process is applicable to any problem.

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[384]Ibid., pp. 25-27.

The flow chart is helpful way of representing and understanding a process. Comparison of the actual work flow with how the process should work "can turn up redundancy, inefficiency and misunderstanding."[385] Figure 26 shows a detailed flow chart of a supplies receiving process.[386]

A histogram is a bar graph used to measure the frequency of an event or occurrence. Figure 27 illustrates the use of a histogram. This histogram portrays the number of daily machine failures to assist in preventive maintenance.[387]

The Pareto diagram is used to prioritize problem areas in a process. The idea implies that rather than concentrating on the least important sources of problems one should concentrate on the essential few. Figure 28 shows how Pareto diagrams are used to measure the improvement in a process.[388] The figure diagrams the process defects before and after improvements were made, allowing comparison of the various sources of problems and the impact of the improvements.

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[385]Walton, p. 102.

[386]Scholtes, p. 2-21.

[387]Ishikawa, p. 12.

[388]Ibid., p. 49.

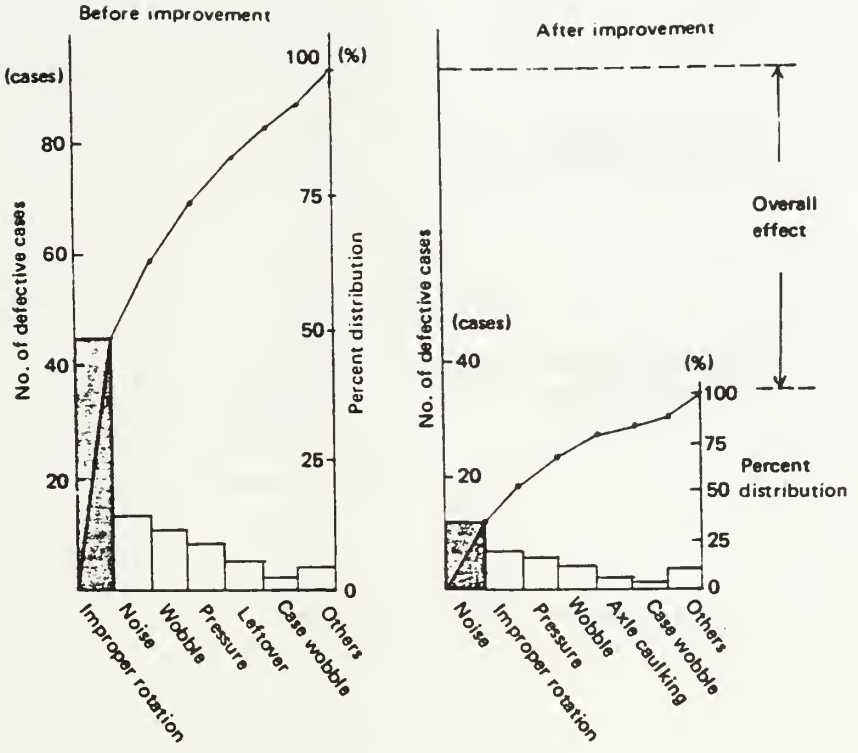

Figure 28 Pareto diagram for process defects.

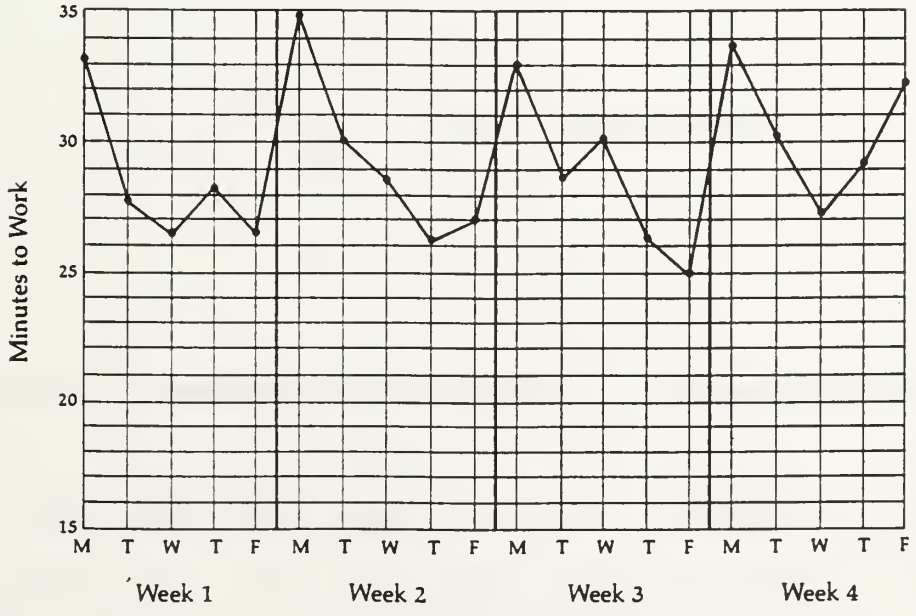

Figure 29 Run chart for documenting travel time.

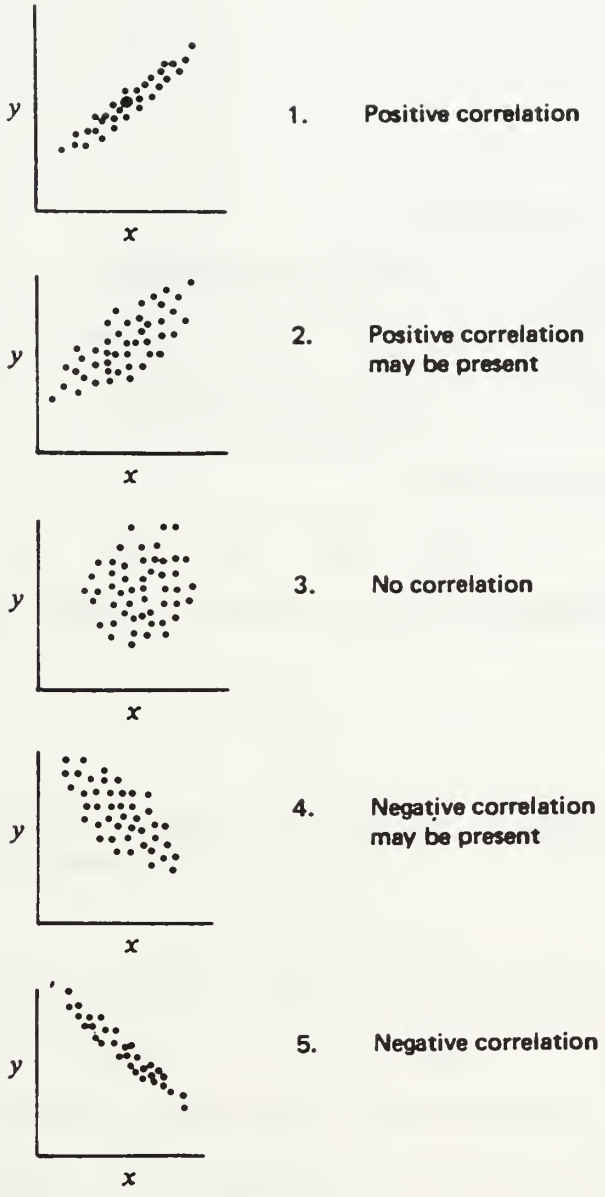

Figure 30 Various plot patterns in scatter diagrams.

Run charts are used to evaluate trends based on data charted over a period of time. Figure 29 shows a simple run chart that documents the travel time to work.[389]

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[389]Walton, p. 108.

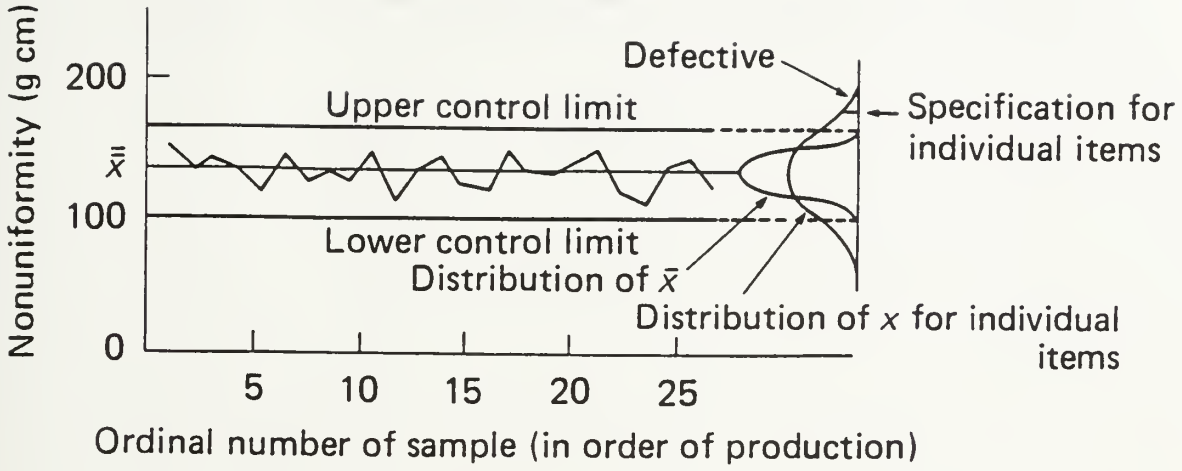

Figure 31 Control chart for test of uniformity of wheels.

The scatter diagram shows the relationship between two types of data. Figure 30 illustrates the various plot patterns in scatter diagrams.[390] The scatter diagram may indicate a positive or negative correlation between variables, or no correlation.

A control chart is a run chart with upper and lower control limits above and below the process mean or average. The upper and lower control limits are an indication of

[390]Ishikawa, p. 91.

process variation prior to making modifications to the process.[391] Figure 31 shows a control chart for testing of the uniformity of wheels produced by a production worker.[392]

[391]Walton, p. 114.

[392]Deming, p. 372.

STATISTICAL QUALITY CONTROL

Barrie and Paulson suggest that statistical quality control is categorized as either (1) quality characteristics that can be *measured* or (2) qualitative observations or *attributes*.[393] Measurable quality characteristics include such items as spacing of columns, compaction density of earth, shear and compressive strength for structural lumber and spacing of reinforcing bars.[394] Qualitative observations include such items as "light bulbs that do or do not illuminate, welds which do or do not pass inspection, electronic control elements that do or do not work, etc."[395]

Statistical properties such as measurements of central tendencies (mean, mode and median) and measures of dispersion (range, variance and standard deviation) are important to the quality control process. The central tendency and dispersion are frequently documented using control charts. Control charts are used to record the average and range of samples, and the average and standard deviation.[396] Barrie and Paulson demonstrate the use of control charts by documenting the average and standard

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[393]Ibid., p. 384.

[394]Ibid.

[395]Ibid.

[396]Ibid.

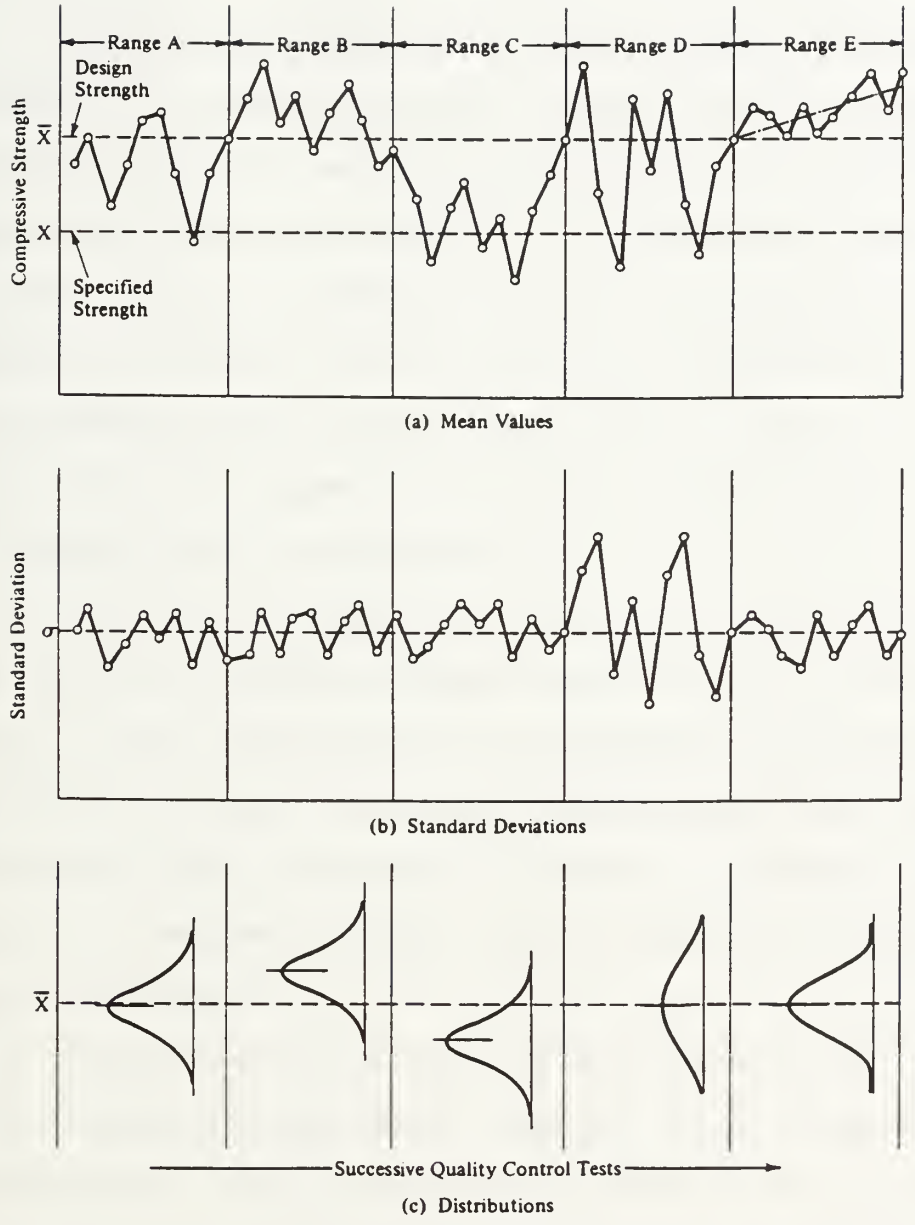

Figure 32 Control charts for mean and standard deviation.

deviation of concrete compressive strengths. These control charts for mean and standard deviation are shown in figure 32.[397]

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[397]Ibid., p. 385.

Figure 32a shows the average or mean of consecutive batches of concrete cylinder breaks. Mean values are indicated on the vertical axis and consecutive tests progress from left to right on the horizontal axis. The tests in range A represent typical performance with good quality of design and good quality of performance. Figure 32b presents the standard deviation for each of the tests, and figure 32c shows the graphical distribution of specific strengths within each batch.

The mean in range B is higher in comparison to the mean in range A, perhaps through overdesign of the concrete mix.[398] Yet, the quality of conformance to the higher standard is about the same, represented by the standard deviation about the mean.[399] The mean in range C is lower than the desired strength, but the quality of conformance is also consistent.

The test results in range D fluctuate about the mean, but the results are widely disperse with larger standard deviations. This situation indicates a lack of control over construction procedures and quality of conformance.[400]

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[398]Ibid., p. 384.

[399]Ibid.

[400]Ibid.

Barrie and Paulson suggest that the gradual trend toward increasing strengths indicated in range E "might indicate continuous wear on a key component in the process — possibly the mechanism that closes the gate that lets the cement into the concrete batch."[401] This observation is an example of how statistical quality control techniques can be used to uncover problem areas in the construction process.

Barrie and Paulson discuss the second category of statistical quality control which deals with sampling by attributes. They explain that "random sampling is used as an economic measure to reduce the expense of testing every unit produced, or in situations involving destructive testing where the element tested is intentionally tested to failure."[402] The premise behind random sampling is that a sample taken from a lot will statistically represent the whole. The reliability of the results increases as the sample size increases. The drawback is that increasing the sample size also increases the cost.

Figure 33 demonstrates the risk and uncertainty in random sampling.[403] The acceptable limit of defectives or quality level is 4 percent. The horizontal axis shows the actual percent defective in a lot and the vertical axis indicates the probability "that a random sample from a lot

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[401]Ibid., p. 385.

[402]Ibid., p. 386.

[403]Ibid., p. 387.

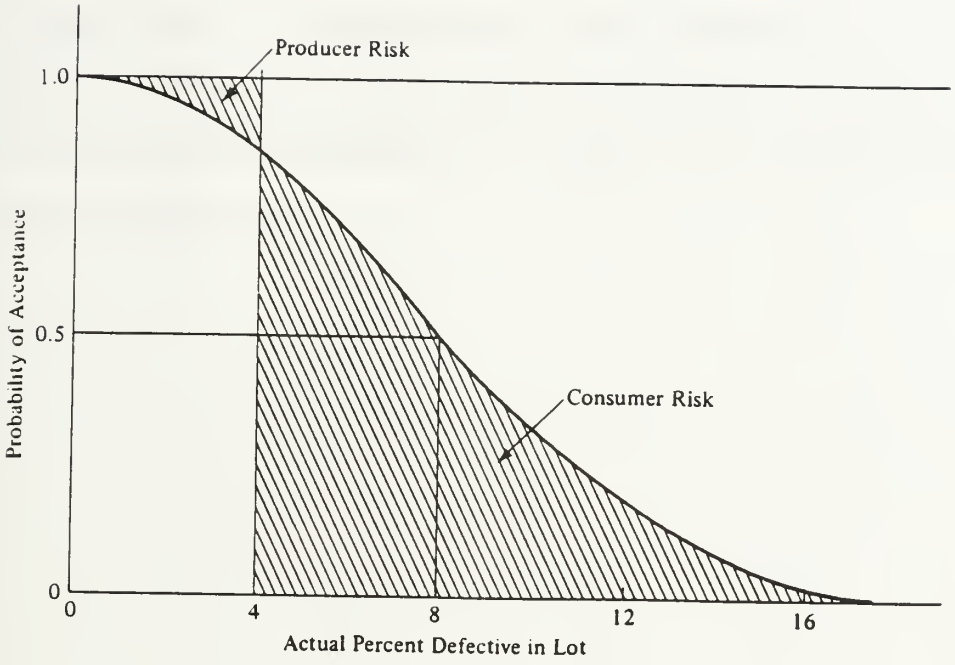

Figure 33 Risk and uncertainty in random sampling.

will show less than 4 percent to be defective."[404] In this case, figure 33 shows that if the lot is 8 percent defective, "there is a 50 percent chance that the sample would contain only 4 percent defectives, and thus allow the whole lot to be accepted."[405] The shaded area to the left of the 4 percent defective line is referred to as the "producer risk". This area represents the probability that a random

[404]Ibid., p. 386.

[405]Ibid.

sample would reject a satisfactory lot.[406] The shaded area to the right is referred to as the "consumer risk". This area "would have to be handled through repair or replacement warranties, or simply have to be absorbed by the consumer."[407]

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[406]Ibid.

[407]Ibid.

MALCOLM BALDRIGE NATIONAL QUALITY AWARD

Public Law 100-107 created the *Malcolm Baldrige National Quality Award* "to promote awareness of quality as a key element in strengthening the position of U.S. business in domestic and international markets."[407] The criteria for the award includes:[408]

- Promotion of quality awareness.
- Identification of requirements for quality excellence.
- Analysis and diagnosis of an organization's quality management system.

The *Malcolm Baldrige National Quality Award* criteria emphasizes both customer satisfaction and continuous improvement. Organizations have both internal and external customers. J. P. Russell portrays customer involvement in the Customer Interaction Venn Diagram shown in figure 34.[409] Russell asserts that continuous quality improvement is dependent on responsiveness to the needs of both internal and external customers.[410]

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[407]J. P. Russell, Quality Management Benchmark Assessment (Milwaukee, Wisconsin: ASQC Quality Press, 1991), p. 1.

[408]Ibid.

[409]Ibid., p. 3.

[410]Ibid., p. 2.

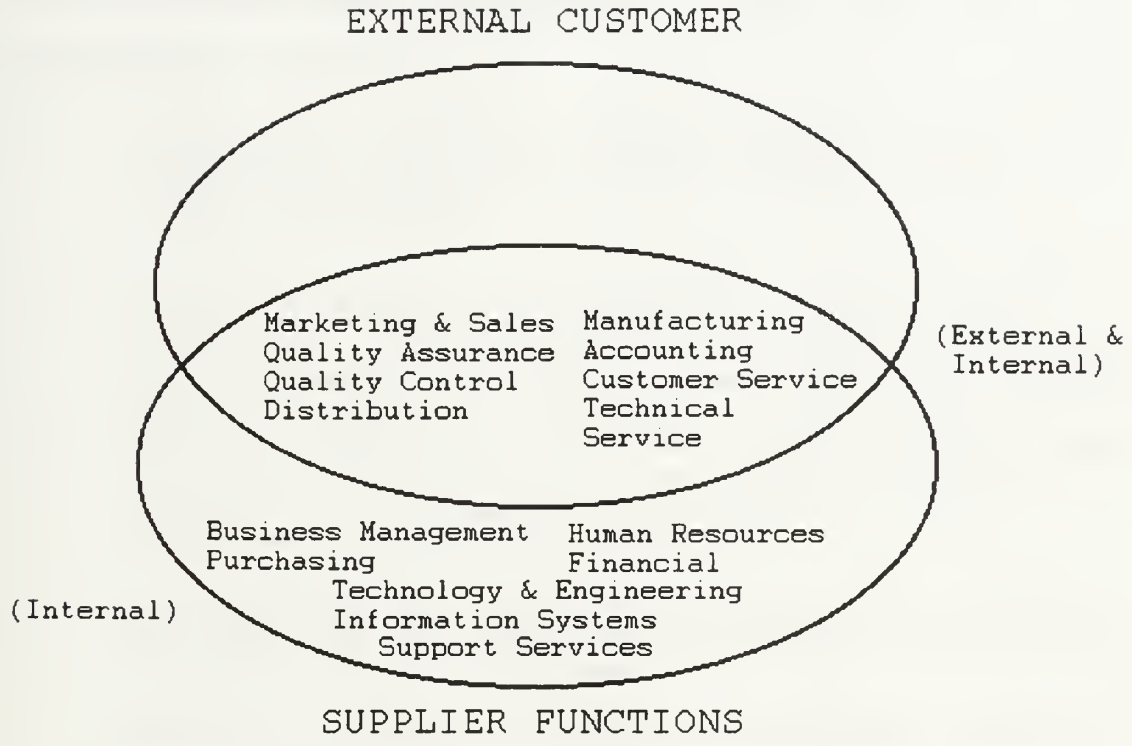

Figure 34 Customer Interaction Venn Diagram.

Continuous quality improvement exists when the organization thrives on methods and processes that foster continuing improvement. The methods and processes should:[411]

- Reduce variation.
- Eliminate root causes when defects or errors occur.
- Prevent occurrence of defects or errors.
- Promote customer feedback — both internally and externally.

[411]Ibid.

Specific business practices and processes are required for continuous quality improvement. Russell says an organization needs:[412]

- A process or system to reduce variation, such as maintaining statistical quality control (SQC) techniques as an integral part of your process control philosophy.

- A prevention style of management. Prevention has two aspects: Preventing recurrence and preventing occurrence. Preventing recurrence means not putting out the same fires over and over again, but tracing and correcting the root cause of each error or defect. Preventing occurrence means doing it right the first time whenever a new product, service or process is introduced. A preventive style of management addresses both aspects.

- A system for data collection and customer feedback. An open line of communication between internal and external customers is essential.

The first recipient of the *Malcolm Baldrige National Quality Award* was the Motorola Corporation. Motorola describes the term *sigma* as "a statistical unit of measurement that describes the distribution about the mean of any process or procedure."[413] *Six Sigma* is "a defect rate of no more than 3.4 per million; statistically, allowing for some variation in mean, this approaches zero defects. . . ."[414]

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[412]Ibid., p. 4.

[413]Motorola, Inc., "Quality Renewal," Information packet from Motorola's Malcolm Baldrige National Quality Award Office, p. 3.

[414]Ibid.

At Motorola, *Six Sigma* is another expression for quality. The corporation's development of a six step methodology was a significant step toward achieving their milestone of *Six Sigma* quality. The six step process was first developed to achieve improvement in manufacturing. Later, the process was expanded to non-manufacturing functions.

Motorola's six steps to *Six Sigma* quality in manufacturing are:[415]

1. Identify product characteristics necessary to satisfy customer physical and functional requirements.
2. Classify identified characteristics as:
   - Part
   - Process
   - Both
3. Determine whether classified characteristic is controlled by:
   - Part
   - Process
   - Both
4. Determine maximum allowable tolerance for each classified characteristic which still guarantees successful performance.
5. Determine process variation for each classified characteristic.
6. Change design of product, process or both to achieve *Six Sigma* capability.

Motorola's six steps to *Six Sigma* quality in non-manufacturing are:[416]

1. Identify the product you create or the service you provide.
2. Identify the customer(s) for your product or service, and determine what they consider important.

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[415]Ibid., Inside cover.

[416]Ibid.

3. Identify your needs (to provide product/service so that it satisfies the customer).
4. Define the process for doing the work.
5. Mistake-proof the process and eliminate wasted effort.
6. Ensure continuous improvement by measuring, analyzing and controlling the improved process.

Identifying the product, product characteristics or service is the first step in both the manufacturing and non-manufacturing methodologies. Motorola suggests that this step is not as simple as it appears. Identifying the customer and their needs is both difficult and important. The corporation must understand what the customer wants and needs in their products in order to direct their product and service lines to meet those wants and needs.

Consequently, Motorola's *Six Sigma* quality initiatives began after establishing their product and clientele. They looked at ways within the organization to provide total product quality. Through customer interface, Motorola concluded that building and marketing good quality products within acceptable defect rates was not enough to remain competitive within today's market. Customers want and expect perfection built into every product they purchase.

Motorola also studied the relationship between a product's early-life field reliability and the frequency of repair during the manufacturing process. They found that "if during a product's manufacture you have to identify and fix defects incurred during its manufacture, you will miss defects that will affect the customer during the early life

of the product."[417] Conversely, Motorola concluded that "if your designs are robust and your manufacturing procedures are controlled so that virtually everything works right the first time, you are highly likely to ship products that will be free from failure in their useful life."[418]

Motorola claims that the *Six Sigma* process has been a critical factor in their success in continuous quality improvement. There has been a trend toward new invention "because the pursuit of *Six Sigma* quality has required dramatic changes in processes and *renewal* of work flows."[419]

Motorola"s conclusions and concept of "robust" design corroborates the message portrayed in Deming's Red Bead Experiment. Walton describes the "moral" of the experiment as:[420]

- Variation is a part of any process.
- Planning requires prediction of how things and people will perform. Tests and experiments of past performance can be useful, but not definitive.
- Workers work within a system, not their individual skills, that determines how they perform.
- Only management can change the system.
- Some workers will always be above average, some below.

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[417]Ibid., p. 3.

[418]Ibid.

[419]Ibid.

[420]Walton, p. 51.

Motorola's key goals are to be the best in their class by outperforming their competition, to increase their market share and to improve their financial standing.[421] These fundamental goals are shared by most civil engineering and construction organizations. Yet, these organizations as a whole have not placed as much priority on providing customers with superior quality products and services. By implementing Motorola's six steps to *Six Sigma* quality, construction organizations are more likely to improve their chance of achieving their customer, profit and market goals.

Motorola's fundamental objective of achieving total customer satisfaction is enhanced by their relationship of trust and respect with suppliers. Their approach to process improvement involves working together with their suppliers to achieve zero defects of incoming materials. This emphasis on improving supplier relationships is clearly applicable to the construction process.

The civil engineering and construction community has the responsibility to design and build facilities that meet customer needs and desires. Through commitment to quality improvement, designers and constructors can meet the expectations of customers and provide total customer satisfaction.

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[421]Motorola, p. 2.

SUMMARY

Total Quality Management allows construction organizations to keep pace with rapidly changing conditions. Through constant improvement of the quality of products and services, Dr. W. Edwards Deming professes that organizations are more likely to stay in business, decrease costs, improve profits and capture markets.

There is a positive relationship between quality and productivity. As the quality improves, costs decrease because of less rework, fewer mistakes, fewer delays and better use of equipment and materials. Consequently, there is an associated improvement in productivity.

Successful organizations must establish a long-term relationship of loyalty and trust with suppliers to improve the quality of incoming materials and to decrease costs. They must also focus on the needs and expectations of the customer or consumer.

Management has the responsibility for improving the system of production. Management must seek quality improvement with constancy of purpose and total commitment. The application of statistical methods is essential to continuous improvement of processes.

Brian E. Mansir and Nicholas R. Schacht portray Deming's management concepts in terms of a "Continuous Improvement Process" model. An organization dedicated to

continuous improvement creates a positive and dynamic working environment, fosters teamwork, applies quantitative methods and analytical techniques and focuses on total customer satisfaction. The key elements of the Continuous Improvement Process (CIP) are the organization's philosophy, principles, practices and techniques and tools for attainment of improvement goals.

The philosophy of an organization represents its shared values, principles and concepts. The organization's philosophy also contains a shared vision which guides the thinking and actions of its members. The CIP organization must establish a clear statement of purpose to unite and focus each of its members. The policies of an organization should reflect the fundamental principles of its philosophy and the concept of continuous improvement. The Department of the Navy, dedicated to continuous improvement, developed a statement of mission, vision and guiding principles for implementation of Total Quality Leadership Navy-wide.

Peter R. Scholtes advocates the use of project teams to improve quality, productivity and processes. The role of teams includes the identification of key processes or areas needing improvement. Managers take part in guidance teams that supervise project teams which are responsible for finding problem solutions. Project teams not only focus on quality improvement of processes but also instill the principles of Quality Leadership throughout the

organization. Teams also aid in the development of internal experts trained in quality improvement techniques.

The Ralph M. Parsons Company is an example of a design-construction company dedicated to continuous quality improvement. The company describes their quality improvement initiatives as the Parsons Quality Improvement Process (QIP). The groundwork for the Parsons QIP is four quality improvement fundamentals called "the absolutes of quality". These fundamentals are presented as answers to questions:[422]

- What is quality? **Conformance to Requirements**
- How do we achieve it? **Prevention**
- What is our performance standard? **Zero Defects**
- How can we measure quality? **Cost of Doing Things Wrong**

Parsons outlines seven elements that comprise their quality improvement program. The first four elements constitute the fundamental structure of the QIP. These elements are organization, education, awareness and recognition. The remaining elements allow each Parsons employee to set in motion the principles of quality improvement. They are defining requirements, measurement and corrective action.

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[422]Parsons, p. 1.

Deming argues that the "Western style of management must change to halt the decline of Western industry, and to turn it upward."[423] The system of improvement or transformation is accomplished through the application of Deming's Fourteen Points and elimination of the Seven Deadly Diseases and Obstacles.

The Fourteen Points are applicable to any type of organization including a government agency, a manufacturing company or a construction company. By adopting the Fourteen Points, management sends a positive signal of continuous improvement to employees, investors and customers alike.

Deming identifies deadly diseases that plague American management and hinder progress toward transformation. The most severe ones are referred to as the Seven Deadly Diseases and those of less severity are called Obstacles. Deming states that elimination of the diseases and obstacles requires a "complete shakeup of Western style of management."[424]

Complementing Deming's management concepts, Mansir and Schacht discuss the principles of continuous improvement. These principles include (1) constancy of purpose, (2) commitment to quality, (3) customer focus and involvement, (4) process orientation, (5) continuous improvement, (6) system-centered management, (7) investment

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[423]Deming, p. 18.

[424]Ibid., p. 97.

in knowledge, (8) teamwork, (9) conservation of human resources, (10) total involvement and (11) perpetual commitment.

Robert D. Martin, the Chairman of Martin Paving Company, believes that Total Quality Management has four basic principles. He calls these principles the "Four Cs of Quality":[425]

- Commitment to error free work.
- Continuous improvement.
- Concentration on prevention.
- Customer knowledge.

Martin challenges the construction industry to adopt the TQM approach. He firmly believes that the TQM approach will result in more profits, reduced costs, enhanced safety and "a better reputation for the construction industry as a whole."[426] He says that "quality assurance programs are just not enough" to ensure continuous improvement.[427]

The American Society of Civil Engineer's *Guide to Quality in the Constructed Project* describes the principles and procedures for achieving quality in the constructed project. The suggestions and recommendations in the guide parallel the principles of Total Quality Management.

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[425]Martin, p. 19.

[426]Ibid.

[427]Ibid.

The guide describes specific responsibilities of each team member. The owner is responsible for project definition and organization, for financial and site acquisition arrangements, for administration of contracts and for operation and maintenance of the completed facility. The design professional is responsible for planning and design, preparation of the construction contract, and construction observation and technical review of submittals prepared by the constructor. The constructor is responsible for construction of the project facilities as specified in the contract, for job-site safety and for protection of public health, safety and the environment.

There are several themes presented in the guide that are important to the quality process. The principal themes include the definition and assignment of responsibilities, importance of teamwork, understanding requirements and expectations, principles of good communication, owner's selection processes for project team members and other important factors which contribute to quality in the constructed project.

The guide discusses the "trend in the construction industry toward statistical analysis for quality control by constructors and suppliers, and for statistically based acceptance criteria by owning agencies."[428] It states that the American Concrete Institute (ACI) provides details on

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[428]American Society of Civil Engineers, p. 72.

statistically based acceptance procedures for concrete and that reports on statistically based specifications are available from the Transportation Research Board. This increased emphasis on statistical methods complements Deming's view that statistical process control is essential to the quality transformation of Western organizations.

The guide indicates that the owner, assisted by the design professional, develops the Quality Assurance and Quality Control program requirements during the early stages of the project. The design professional prepares and implements the program during the design phase. The design professional employs quality management procedures "to improve thought processes, clarify communications among team members and to transfer the concepts and mental images of the project . . . to physical structures and systems to be built by the constructor."[429] The constructor's role is to comply with contract quality requirements during the construction phase of the project. The guide stresses that quality depends on total commitment and mutual understanding by all the team members.

Donald S. Barrie and Boyd C. Paulson suggest that the "basic elements of quality" include quality *characteristics,* quality of *design* and quality of *conformance.*[430] Quality characteristics are "properties that define the nature of a

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[429]Ibid., p. 84.

[430]Barrie and Paulson, p. 372.

product for quality control purposes" such as dimension, color, strength or temperature.[431] The quality of design involves the tolerances or ranges for acceptable variation from the standard specified for the product. The quality of conformance is the extent to which the construction effort complies with the specified standard.

The Partnering process is a new concept in the construction industry that compliments Total Quality Management. Partnering involves the members of the construction team in the development of a strategy for the purpose of avoiding disputes, fostering a cooperative spirit and facilitating successful completion of the project.

The are several types of charts that are useful for presenting data and understanding processes. These charts include the cause-and-effect diagram, flow chart, Pareto chart, run (trend) chart, histogram, control chart and scatter diagram.

Barrie and Paulson suggest that statistical quality control is categorized as either (1) quality characteristics that can be *measured* or (2) qualitative observations or *attributes*.

Statistical properties such as measurements of central tendencies (mean, mode and median) and measures of dispersion (range, variance and standard deviation) are important to the quality control process. The central

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[431]Ibid.

tendency and dispersion are frequently documented using control charts. Control charts are used to record the average and range of samples, and the average and standard deviation.

Barrie and Paulson explain that "random sampling [by attributes] is used as an economic measure to reduce the expense of testing every unit produced, or in situations involving destructive testing where the element tested is intentionally tested to failure."[432] The premise behind random sampling is that a sample taken from a lot will statistically represent the whole. The reliability of the results increases as the sample size increases. The drawback is that increasing the sample size also increases the cost.

Public Law 100-107 created the *Malcolm Baldrige National Quality Award* "to promote awareness of quality as a key element in strengthening the position of U.S. business in domestic and international markets."[433] The criteria for the award emphasizes both customer satisfaction and continuous improvement.

The first recipient of the *Malcolm Baldrige National Quality Award* was the Motorola Corporation. Motorola describes the term *sigma* as "a statistical unit of measurement that describes the distribution about the mean

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[432]Ibid., p. 386.

[433]Russell, p. 1.

of any process or procedure."[434] *Six Sigma* is "a defect rate of no more than 3.4 per million; statistically, allowing for some variation in mean, this approaches zero defects. . . ."[435]

At Motorola, *Six Sigma* is another expression for quality. The corporation's development of a six step methodology was a significant step toward achieving their milestone of *Six Sigma* quality. The six step process was first developed to achieve improvement in manufacturing. Later, the process was expanded to non-manufacturing functions.

Motorola's key goals are to be the best in their class by outperforming their competition, to increase their market share and to improve their financial standing. These fundamental goals are shared by most civil engineering and construction organizations. Yet, these organizations as a whole have not placed as much priority on providing customers with superior quality products and services. By implementing Motorola's six steps to *Six Sigma* quality, construction organizations are more likely to improve their chance of achieving their customer, profit and market goals.

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[434]Motorola, p. 3.

[435]Ibid.

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